Massachusetts Residential Building Use and Equipment Characterization Study

Phase 8

Prepared for:
The Electric and Gas Program Administrators of Massachusetts
Part of the Residential Evaluation Program Area

Submitted by:

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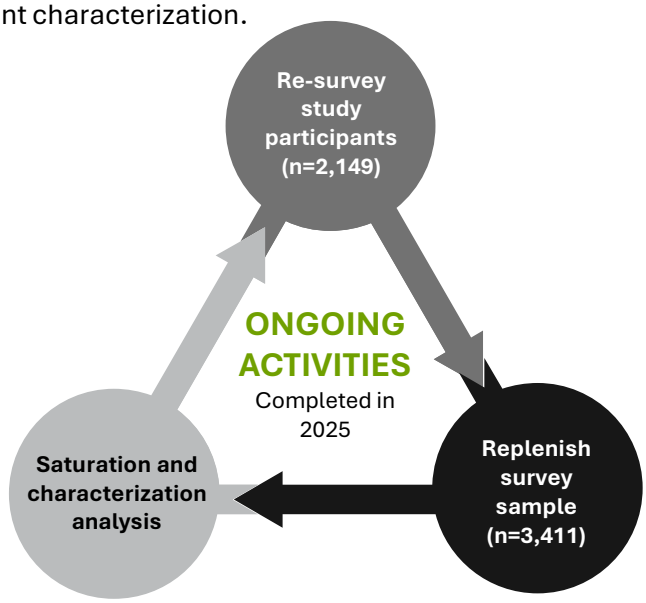
Study Overview

The Phase 8 Residential Building Use Equipment Characterization Study provides a comprehensive, survey-based assessment of residential building use and equipment in Massachusetts. The study collects saturation, characterization, and usage behavior data for all major electric and gas appliances, mechanical systems, and electronics in Massachusetts homes.

In the first year of the study, Guidehouse (formerly Navigant) surveyed thousands of Massachusetts residents about their household appliances and energy use and metered 25 electric end uses at over 350 homes. In this eighth year of the study, Guidehouse continued the survey data collection activities to calculate updates and changes in saturation and equipment characterization.

INITIAL ACTIVITIES
Completed in 2017

- **Conduct online survey**
- **Draw onsite sample**
- **Install meters at sampled homes**



What Is New in Phase 8:

- **Transition to Survey-Only Data Collection:**
  All data in Phase 8 was collected via online surveys.
- **Expanded Survey Content and Targeting:**
  The survey instrument was updated to reflect evolving priorities in energy affordability, decarbonization, and demographic representation—including Environmental Justice Communities, non-English speakers, renters, and low-income households.
- **Enhanced Outreach:**
  Survey and recruitment materials were translated into Spanish and Brazilian Portuguese to improve inclusivity.

How the Data Is Used:
The results inform future energy efficiency and demand response potential studies, update effective useful life (EUL) values in the Massachusetts Technical Reference Manual (TRM), and provide actionable insights for future energy efficiency programs.

Note: Metered electric load shape data is not included in Phase 8, as all data collection was survey-based. For historical load shape trends, refer to previous phases.

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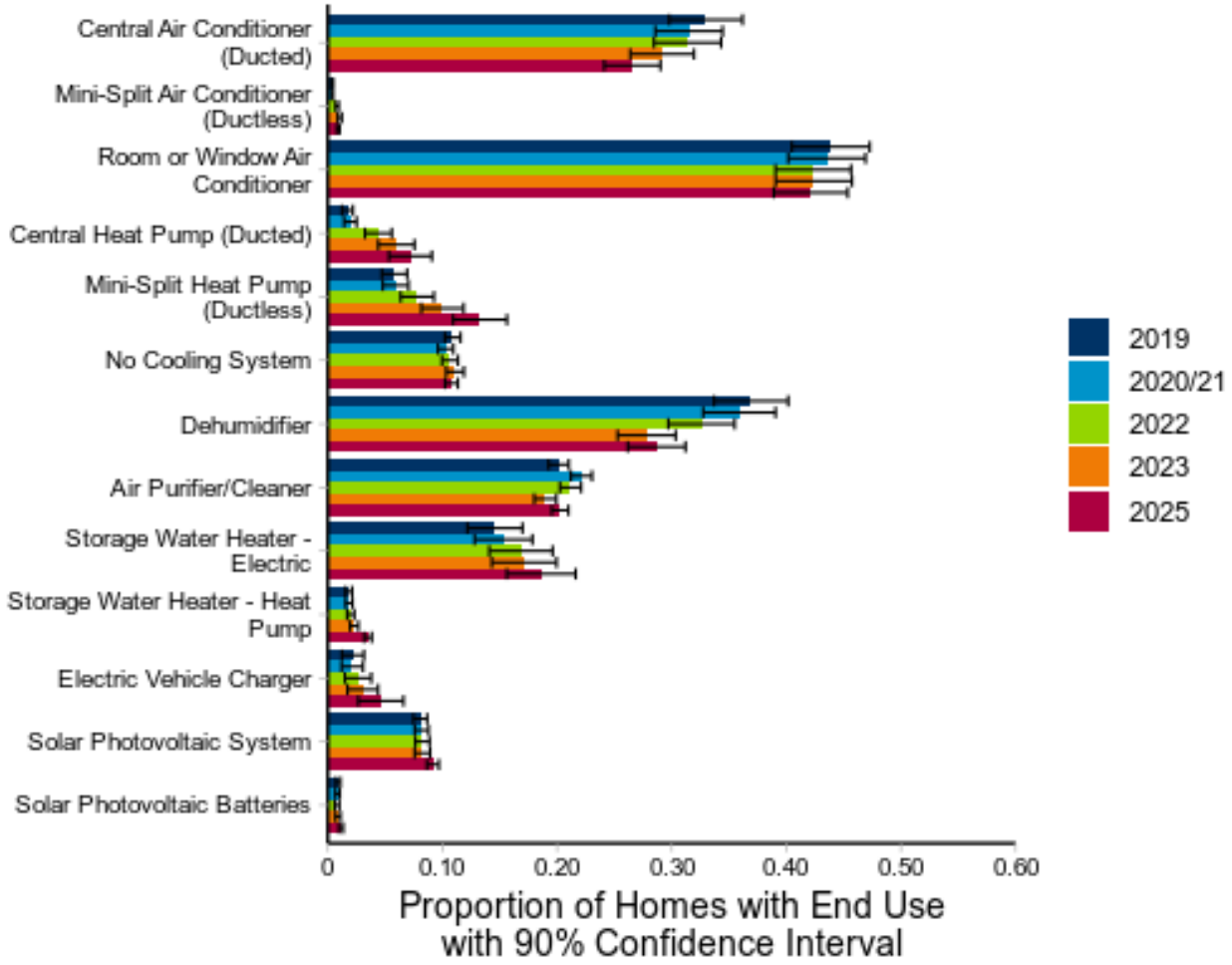
Electric End Use Saturation Trends

Change in End Use Saturation Over Time



The proportion of homes with **mini-split and central heat pumps** continues to rise steadily through 2025, reflecting increased adoption of electrification technologies and the impact of Mass Save programs. This growth suggests that more households are choosing heat pumps for both heating and cooling needs.

Saturation of **central ducted air conditioners** has declined in recent years. This trend may indicate a shift toward heat pump systems as replacements for traditional cooling equipment.

The proportion of homes with **dehumidifiers** has decreased in recent years, potentially due to improved humidity control from HVAC systems.

Electric storage water heaters remain common, while **heat pump water heater** adoption is beginning to increase, signaling early market growth.

Saturation of **electric vehicle (EV) chargers** and **solar photovoltaic (PV) systems** continues to increase, highlighting ongoing interest in decarbonization and emerging technologies.

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Electric and Internet-Connected End Use Saturations

Electric End Use Saturations

End Use	Saturation
Central Air Conditioner (Ducted)	26%
Room or Window Air Conditioner	42%
Electric Baseboard Heat	16%
Mini-Split Heat Pump (Ductless)	13%
Mini-Split Air Conditioner (Ductless)	1%
Central Heat Pump (Ducted)	7%
Air-to-Water Heat Pump	1%
Furnace – Electric	1%
Ground Source Heat Pump	1%
Space Heater or Plug-In Fireplace	17%
Dehumidifier	29%
Refrigerator	100%
Freezer	20%
Dishwasher	77%
Oven or Range – Electric	48%
Cooktop – Electric	5%
Storage Water Heater – Electric	18%
Tankless Water Heater – Electric	3%
Storage Water Heater – Heat Pump	3%
Clothes Washer	79%
Clothes Dryer – Electric	62%
Pool Pump	5%
Solar Photovoltaic System	9%
Solar Photovoltaic Batteries	1%
TV	89%
Smart Phone	89%
Electric Vehicle	7%

Internet-Connected End Use Saturations

End Use	Saturation
Thermostat	23%
Dehumidifier	3%
Refrigerator	9%
Oven or Range – Electric	5%
Oven or Range – Natural Gas	5%
Storage Water Heater – Electric	3%
Clothes Washer	10%
Clothes Dryer – Electric	7%
Clothes Dryer – Natural Gas	2%
TV	37%
Smart Speaker or Hub	26%
Lights	11%
Lighting Controls	6%
Outlets	15%
Sound System	6%
Cameras	19%
Irrigation System	2%

Slightly less than half of homes (42%) have **room or window air conditioners**. Seven percent of homes have one or more **EVs**.

Internet-connected devices continue to gain adoption in Massachusetts. The increasing prevalence of internet-connected devices represents an opportunity for new demand response and load shifting program design options.

Natural Gas and Fuel Oil End Use Saturations

Non-Electric End Use Saturations

End Use	Saturation
Furnace – Natural Gas	25%
Furnace – Fuel Oil	5%
Boiler – Natural Gas	29%
Boiler – Fuel Oil	15%
Fireplace – Natural Gas	6%
Fireplace or Heating Stove – Other Fuel	16%
Oven or Range – Natural Gas	41%
Cooktop – Natural Gas	3%
Storage Water Heater – Natural Gas	37%
Tankless Water Heater – Natural Gas	9%
Storage Water Heater – Fuel Oil	1%
Tankless Water Heater – Fuel Oil	2%
Storage Water Heater – Indirect	14%
Clothes Dryer – Natural Gas	18%
Pool Heater – Natural Gas	1%
Hot Tub – Natural Gas	<1%

Massachusetts has a significant number of homes that heat with fuel oil, although the saturation is decreasing over time.

Space heating systems (furnaces and boilers) using natural gas and fuel oil remain common in Massachusetts homes, but their saturation is gradually declining as households transition to alternative heating technologies.

Space heating continues to be the primary driver of natural gas use, accounting for approximately **83% of annual consumption** and **95% of winter peak demand**.

Cooking appliances (oven/range and cooktop) and **water heating equipment** (storage and tankless water heaters) represent significant shares of natural gas end uses.

Clothes dryers powered by natural gas are present in nearly one-fifth of homes.

Fuel oil is still used for heating and water heating in a subset of homes, but adoption rates are low and trending downward.

Specialty uses (pool heaters, hot tubs) have minimal saturation.

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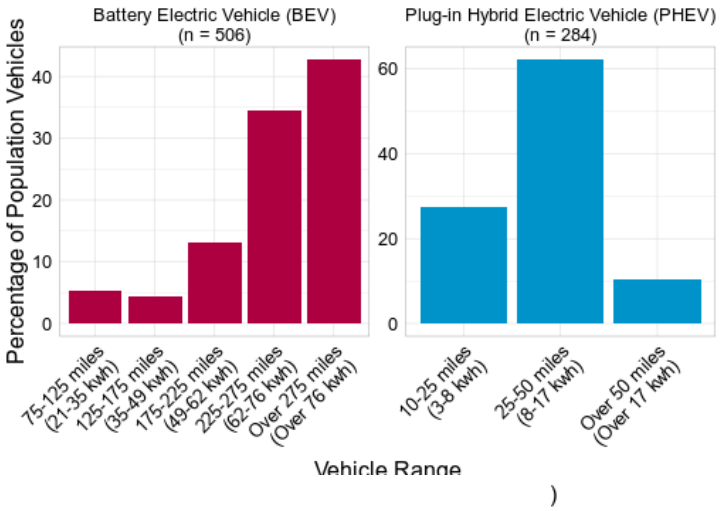
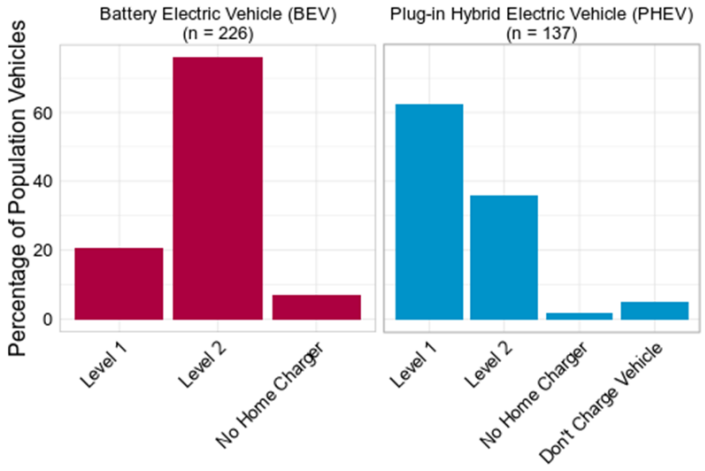
EV Characteristics

EV Range



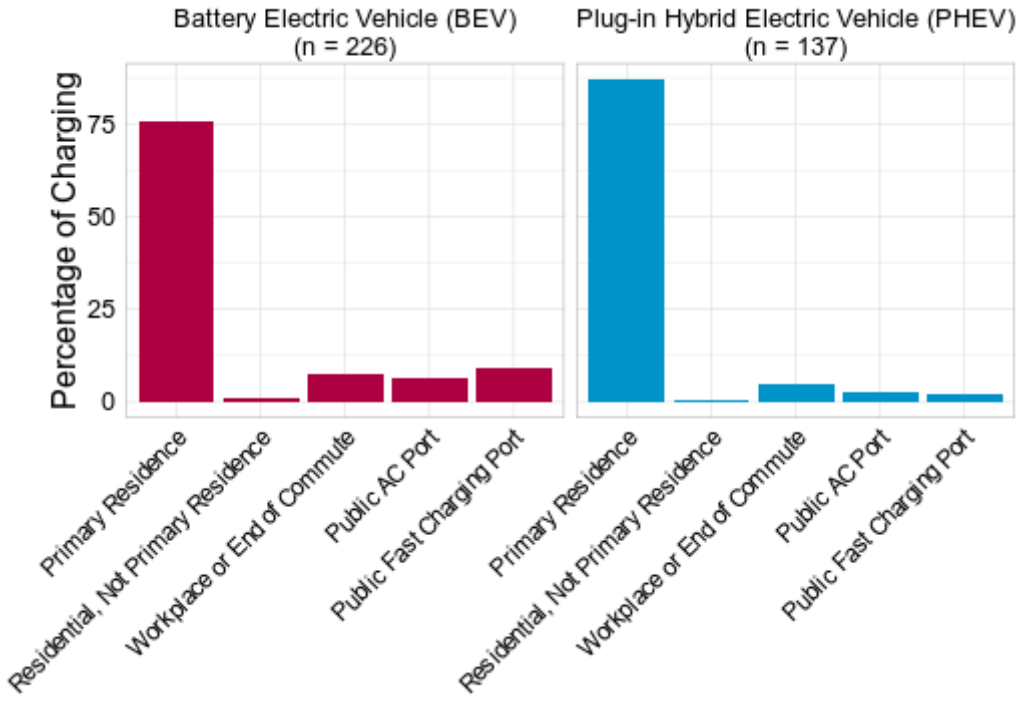
Of EVs owned, **63% are battery electric vehicles (BEVs) and 37% are plug-in hybrid electric vehicles (PHEVs).** About 89% of BEVs are high capacity (175+ miles).

EV Charger Type



Most BEV owners have a Level 2 charger (240 V), while most PHEV owners have a Level 1 charger (120 V). About 7% of BEV owners and 2% of PHEV owners do not own a home charger. About 5% of PHEV owners do not charge their vehicle.

EV Charging Location



The vast majority of EV charging occurs at home (75% for BEVs and 87% for PHEVs). Workplace and Public AC or Fast Charging account for the remainder of charging (5-8% each for BEVs and 2-5% each for PHEVS).

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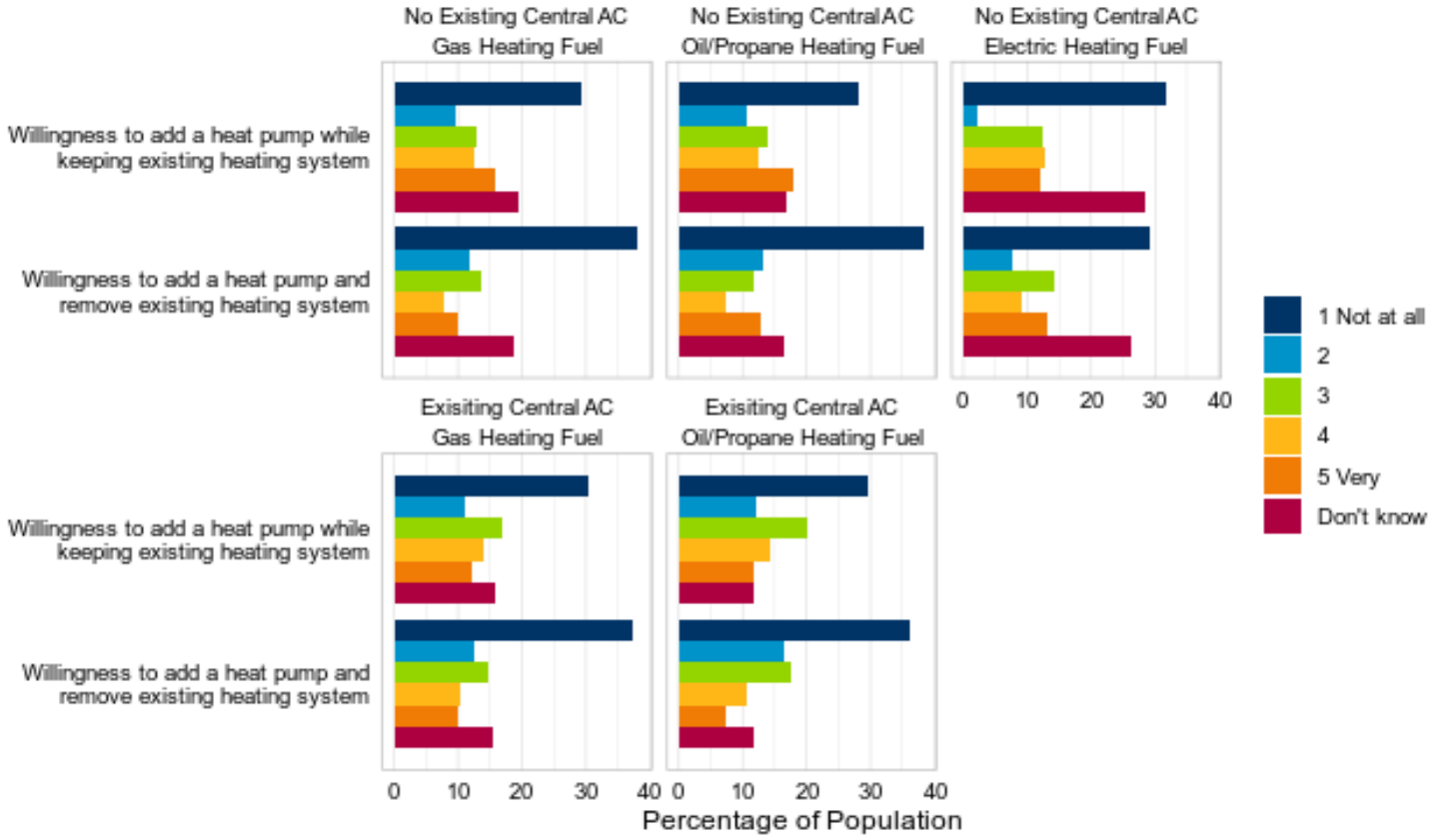
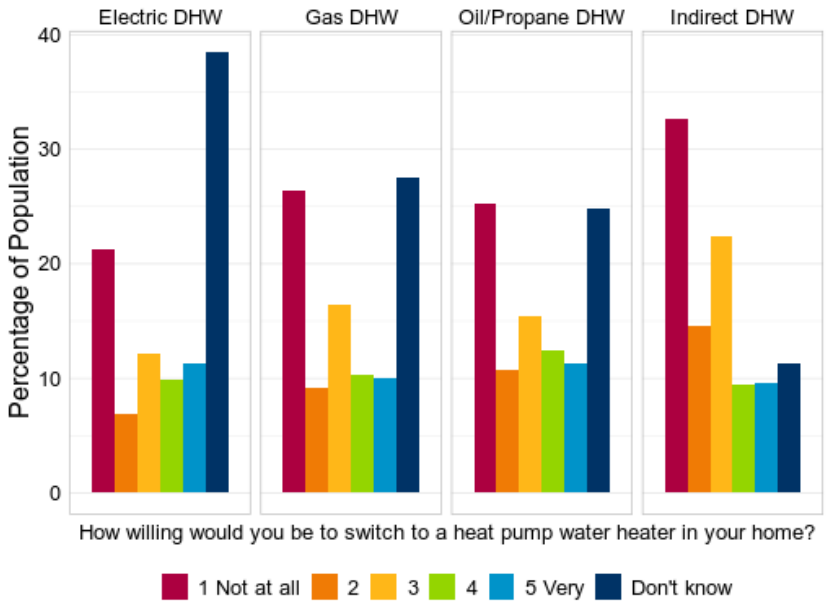
Heat Pump and Heat Pump Water Heater Adoption

Heat Pump Adoption by Current Heating System Type



Heat Pump Water Heater Adoption



Approximately **10%-30%** of respondents indicated they were **willing to switch their HVAC system to a heat pump, with greater willingness when they can maintain their backup system**.

Barriers for increased heat pump adoption include the **initial upfront cost, concerns about higher heating bills, limited understanding of system operation, and performance concerns.**

Only **about 20%** of the population expressed willingness to **switch to a heat pump water heater**, although **over 60%** of the population indicated they **had not heard of heat pump water heaters.**

Developed by:

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Table of Contents

1. Introduction 1
1.1 Document Orientation 1
1.2 Study Goals 2
1.3 Summary of Research Activities 2
1.4 Updates from Previous Phases of the Study 5
1.5 Terminology 5
1.6 Abbreviations 5
2. Results and Key Findings 8
2.1 Saturation of Key End Uses 8
2.1.1 Saturation of Notable Electric End Uses 8
2.1.2 Saturation of Gas and Oil End Uses 10
2.1.3 Saturation of Internet-Connected End Uses 16
2.1.4 Saturation Differences by Building Type 18
2.2 Electric Vehicle Characteristics 21
2.3 Income vs. Energy Expenditures 28
2.4 Heat Pump Adoption 40
2.4.1 Willingness to Install a Heat Pump 42
2.4.2 Heat Pump Installation and Purchase Decisions 48
2.4.3 Heat Pump Maintenance Issues 52
2.5 Heat Pump Water Heater Adoption 57
2.6 Electrification Readiness 61
2.6.1 100A Panel Electrification Readiness 62
2.6.2 200A Panel Electrification Readiness 64
2.6.3 Electrical Panel Load Management 66
3. Detailed Findings 68
3.1 HVAC End Uses 68
3.2 Kitchen End Uses 97
3.3 Laundry End Uses 103
3.4 Water Heating End Uses 108
3.5 Miscellaneous End Uses 118
3.6 Building Characteristics 130
3.7 TRM Inputs 134
4. Overall Conclusions and Considerations 135
4.1 Conclusions 135

4.2 Considerations 136
Appendix A. Methods A-1
A.1 Online Survey A-1
A.2 Data Analysis A-10
Appendix B. Supporting Data B-1

List of Figures

Figure 2-1. 2025 Saturation for Select End Uses 8
Figure 2-2. Saturation Trends for Select End Uses 9
Figure 2-3. Gas End Use Saturation 10
Figure 2-4. Proportion of Homes that Purchased Gas End Uses in the Past Year 11
Figure 2-5. Proportion of Existing Gas Units Replaced or Retired in the Past Year 12
Figure 2-6. Oil End use Saturation 13
Figure 2-7. Proportion of Homes that Purchased Fuel Oil End Uses in the Past Year 14
Figure 2-8. Proportion of Existing Oil Units Replaced or Retired in the Past Year 15
Figure 2-9. Saturation of Internet-Connected End Uses 16
Figure 2-10. Proportion of Homes that Added Internet-Connected Equipment in the Past Year 17
Figure 2-11. Notable Cooling Saturation Differences by Building Type 18
Figure 2-12. Notable Heating Saturation Differences by Building Type 19
Figure 2-13. Notable Other Saturation Differences by Building Type 20
Figure 2-14. EV Types 21
Figure 2-15. EV Manufacturers 22
Figure 2-16. EV Years of Manufacture 23
Figure 2-17. Self-Reported EV Range 24
Figure 2-18. Home EV Charger Type 25
Figure 2-19. Self-Reported Percentage of EV Charging by Location 26
Figure 2-20. Self-Reported EV Charging Behavior 27
Figure 2-21. Income Changes in 2024 28
Figure 2-22. Behavior Changes to Save on Energy Bills 29
Figure 2-23. Energy Consumption Behavior Changes 30
Figure 2-24. Customer Ability to Pay for Household General Expenses 31
Figure 2-25. Customer Ability to Pay for Household Energy Expenses 32
Figure 2-26. Monthly Energy Bills by Fuel Type and Season 33
Figure 2-27. Annual Energy Bills by Fuel Type 34
Figure 2-28. Total Annual Energy Bills by Fuel Types in Home 35
Figure 2-29. Annual Energy Bills as a Percentage of Income by Fuel Type 36
Figure 2-30. Annual Energy Bills as a Percentage of Income for All Fuel Types in Home 37
Figure 2-31. Percentage of Population Who Received Financial Assistance Services 38
Figure 2-32. Percentage of Population Who Claimed an Energy Efficient Credit on Their 2023 Tax Return 39
Figure 2-33. Population Awareness of Heat Pumps and Heat Pump Water Heaters 40
Figure 2-34. Population Knowledge of Heat Pump Heating and Cooling Capabilities 41
Figure 2-35. Heat Pump Willingness by Current Heating Fuel and Cooling System* 42
Figure 2-36. Rationale for Not Yet Switching to a Heat Pump System for Interested Customers 43

Figure 2-37. Rationale for Not Switching to a Heat Pump System for Non-Interested Customers . 44
Figure 2-38. Contractor Advice Given Against Using a Heat Pump for Heating 45
Figure 2-39. Percentage of Population Who Plan to Install Air Conditioning in the Next Few Years 46
Figure 2-40. Types of Heat Pumps Interested Customers Would Consider Installing 47
Figure 2-41. Heat Pump Year of Installation 48
Figure 2-42. Percentage of Population Who Will Receive a Federal Tax Credit on Their Heat Pump Purchase 49
Figure 2-43. Percentage of Population Who Received a Rebate from Mass Save 50
Figure 2-44. Influential Attributes on the Decision to Install a Heat Pump 51
Figure 2-45. Maintenance Issues Experienced by Heat Pump Type 52
Figure 2-46. Maintenance Issues Experienced by Install Year and Participation 53
Figure 2-47. Frequency of Refrigerant Leakage by Heat Pump Type for Those Who Reported a Leak 54
Figure 2-48. Total Refrigerant Leaks by Heat Pump Type 55
Figure 2-49. Average Cost to Repair Refrigerant Leakage Per Leak 56
Figure 2-50. Heat Pump Water Heater Willingness to Adopt by Existing Water Heater Type 57
Figure 2-51. Rationale for Not Yet Switching to a Heat Pump Water Heater for Interested Customers 58
Figure 2-52. Rationale for Not Switching to a Heat Pump Water Heater for Customers Who Are Not Interested in Switching 59
Figure 2-53. Heat Pump Water Heater Type 60
Figure 2-54. Panel Capacities in Studied Sample 61
Figure 2-55. 100A Panel Existing Capacities 62
Figure 2-56. Capacity of 100A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and EV Chargers 63
Figure 2-57. 200A Panel Existing Capacities 64
Figure 2-58. Capacity of 200A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and a 60A EV Charger 65
Figure 2-59. Capacity of 200A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and Two 60A EV Chargers 66
Figure 2-60. Customer-Reported Smart Panels in Studied Sample 67
Figure 3-1. HVAC Cooling Equipment Saturation 68
Figure 3-2. Proportion of Homes that Purchased Cooling Season HVAC End Uses in the Past Year69
Figure 3-3. Proportion of Cooling Season HVAC End Uses Replaced or Retired in the Past Year ... 70
Figure 3-4. HVAC Cooling Equipment Saturation Trends 71
Figure 3-5. Primary Cooling System Saturation 72
Figure 3-6. New Central Air Conditioning/Heat Pump Efficiencies 73
Figure 3-7. New Mini-Split Air Conditioner/Heat Pump Efficiencies 74
Figure 3-8. New Room/Window Air Conditioner Efficiencies (EER) 75
Figure 3-9. Existing and New Room/Window Air Conditioner Efficiencies (CEER) 76
Figure 3-10. New Room/Window Air Conditioner Efficiencies as a Ratio of Code Minimum Efficiency 77
Figure 3-11. HVAC Heating Equipment Saturation 78
Figure 3-12. Proportion of Homes that Purchased Heating Season HVAC End Uses in the Past Year 79
Figure 3-13. Proportion of Existing Heating Season HVAC Units Replaced or Retired in the Past Year 80

Figure 3-14. HVAC Heating Equipment Saturation Trends 81
Figure 3-15. Primary Heating System Type 82
Figure 3-16. Primary Heating System Fuel 83
Figure 3-17. New Gas Furnace Efficiencies 84
Figure 3-18. New Gas Boiler Efficiencies 85
Figure 3-19. Self-Reported Heat Pump Control Type 86
Figure 3-20. Heat Pump System Integrated Backup Heat 87
Figure 3-21. Steam vs. Hot Water Boiler 88
Figure 3-22. Primary Heating System Performance During Cold Snap 89
Figure 3-23. Primary HVAC System Ages 90
Figure 3-24. Miscellaneous HVAC Equipment Saturation 91
Figure 3-25. Proportion of Homes that Purchased New Miscellaneous HVAC Equipment in the Past Year 92
Figure 3-26. Proportion of Existing Miscellaneous HVAC Units Replaced or Retired in the Past Year 93
Figure 3-27. Miscellaneous HVAC Equipment Saturation Trends 94
Figure 3-28. Self-Reported Dehumidifier Control Type 95
Figure 3-29. Self-Reported Dehumidifier Drain Type 96
Figure 3-30. Kitchen End Use Saturation 97
Figure 3-31. Proportion of Homes that Purchased New Kitchen End Uses in the Past Year 98
Figure 3-32. Proportion of Existing Kitchen Units Replaced or Retired in the Past Year 99
Figure 3-33. Kitchen End use Saturation Trends 100
Figure 3-34. Electric Cooktop and Range Types 101
Figure 3-35. New Primary Refrigerator DOE-Estimated Annual Energy Use 102
Figure 3-36. Laundry End Use Saturation 103
Figure 3-37. Proportion of Homes that Purchased New Laundry Equipment in the Past Year 104
Figure 3-38. Proportion of Existing Laundry Units Replaced or Retired in the Past Year 105
Figure 3-39. Laundry End use Saturation Trends 106
Figure 3-40. New Clothes Washer Efficiencies 107
Figure 3-41. Water Heating End Use Saturation 108
Figure 3-42. Water Heating Fuel 109
Figure 3-43. Indirect Water Heater Fuel 110
Figure 3-44. Proportion of Homes that Purchased New Water Heating-Related Equipment in the Past Year 111
Figure 3-45. Proportion of Existing Water Heating-Related Equipment Replaced or Retired in the Past Year 112
Figure 3-46. Water Heating End use Saturation Trends 113
Figure 3-47. New Gas Storage Water Heater Efficiencies 114
Figure 3-48. New Electric Resistance Storage Water Heater Efficiencies 115
Figure 3-49. Age of Existing Water Heaters 116
Figure 3-50. Water Heaters with Insulation Blanket or Tank Wrap 117
Figure 3-51. Miscellaneous End Use Saturation – Outdoor 118
Figure 3-52. Proportion of Homes that Purchased New Miscellaneous Equipment –Outdoor 119
Figure 3-53. Miscellaneous Outdoor Saturation Trends 120
Figure 3-54. Miscellaneous End use Saturation – Garage 121
Figure 3-55. Proportion of Homes that Purchased New Miscellaneous Equipment – Garage 122

Figure 3-56. Proportion of Existing Miscellaneous Garage Units Replaced or Retired in the Past Year 123
Figure 3-57. Miscellaneous Garage Saturation Trends 124
Figure 3-58. Fuel Type for Backup Generator 125
Figure 3-59. Miscellaneous End use Saturation – Electronics 126
Figure 3-60. Proportion of Homes that Purchased Miscellaneous Equipment – Electronics 127
Figure 3-61. Proportion of Existing Miscellaneous Electronics Units Replaced or Retired in the Past Year 128
Figure 3-62. Miscellaneous Electronics Saturation Trends 129
Figure 3-63. Window Type by Income Level 130
Figure 3-64. Window Age by Income Level 131
Figure 3-65. Percentage of Population Who Installed or Upgraded Insulation 132
Figure 3-66. Percentage of Population Who Has Tested and Sealed Air Leaks 133

Figure A-1. Population vs. Survey Demographics A-12
Figure A-2. Example Panel Photograph A-14

List of Tables

Table 1-1. Study Activities by Phase and Year 4
Table 3-1. EUL by End Use 134
Table 4-1. Key Conclusions and Considerations 138

Table A-1. Follow-Up Survey Recruitment Summary A-2
Table A-2. Sample Size A-4
Table A-3. Targeting Categories for Sampling Waves A-5
Table A-4. Survey Recruitment Summary A-9
Table B-1. Appendix B Supporting Document File Names and Contents B-1

1. Introduction

Guidehouse, Inc. (hereafter "Guidehouse" or "the team") has undertaken a comprehensive, multiyear study to characterize residential building use and equipment in Massachusetts, leveraging data collected through annual online surveys. Phase 8 of the Residential Building Use and Equipment Characterization (RBUEC) study builds on previous phases,[1] continuing the annual survey effort to deepen understanding of energy consumption patterns in Massachusetts homes.

This research is designed to provide the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) consultants with detailed, actionable insights into how residents use energy, focusing on both market-rate and income-eligible households. The survey captures saturation rates for major electric and gas appliances, mechanical systems, and electronics, offering a granular view of equipment prevalence and usage across the state.

Beyond equipment saturation, the study aims to identify opportunities for reducing overall energy consumption and supporting the development of future energy efficiency programs. This comprehensive report presents findings from the inception of the study in 2017 through the latest data collection period in Phase 8 (March 2024–September 2025), reflecting the evolution of residential energy use and technology adoption in Massachusetts.

1.1 Document Orientation

This report provides a comprehensive summary of saturation and characterization data for residential buildings in Massachusetts, analyzed both at the population level and across key demographic and building type categories. The organization of the report is designed to guide readers from high-level insights to detailed findings and supporting data:

- **Section 1 – Introduction:** Outlines the study's objectives, research activities, and updates since the previous comprehensive report (2023).
- **Section 2 – Results and Key Findings:** Presents trends in equipment saturation and changes from 2023 to 2025 for major electric, gas, and oil end uses, as well as internet-connected devices. This section also examines income versus energy expenditures and adoption rates for heat pumps and heat pump water heaters.
- **Section 3 – Detailed Findings:** Expands on the key results, providing in-depth saturation and characterization data for each end-use category, including survey-based insights.
- **Section 4 – Overall Conclusions and Considerations:** Summarizes the main conclusions and broader implications drawn from the study's findings.
- **Appendix A – Methods:** Details the methodology used for the online survey and data analysis.

[1] Guidehouse, Massachusetts Residential Building Use and Equipment Characterization Study, December 22, 2023, https://ma-eeac.org/wp-content/uploads/Residential-Building-Use-and-Equipment-Characterization-Study-Comprehensive-Report-2023-12-22.pdf.

- **Appendix B – Supporting Data:** Contains supplementary findings and datasets, including additional charts and graphics for each research area. Notably, this appendix includes:
    - Detailed plots and datasets showing saturation rates and the number of units added or removed over the past year, broken out by demographic and building characteristics such as building type, heating type, income level, education, language spoken, and program participation
    - Data on existing and newly installed unit efficiencies, capacities, year of manufacture, and other characteristics, such as annual water consumption

1.2 Study Goals

The primary goal of the RBUEC study is to collect data on saturation, characterization, and key explanatory variables for all major electric and gas appliances, mechanical equipment, and electronics in Massachusetts homes. This data provides the foundation for informing future energy efficiency and demand response (DR) potential studies, updating the effective useful life (EUL) values in the Massachusetts Technical Reference Manual (TRM), and providing actionable insights for future energy efficiency programs. The secondary goal of this study is to support other research that the PAs are undertaking—such as market effects and opportunities research—by providing comprehensive data for the sampled customers.

This report is intended to answer the following primary and secondary research questions stated in the study's Stage 3 plan.

Continuation of Phases 2 through 7 Research Questions:

- How are the saturation and characteristics of energy-consuming equipment present in Massachusetts homes changing over time?
- How quickly are Massachusetts residents adopting energy efficient and emerging technologies, such as heat pump water heaters, ductless heat pumps, EVs; connected major appliances, such as electric water heaters and clothes dryers; and smart electric panels and other smart home devices?
- How ready are Massachusetts homes for electrification?
- What is the energy burden of Massachusetts residents?

In this report, Guidehouse presents key findings from the data collected between March 2017 and September 2025.

1.3 Summary of Research Activities

This study's research approach and activities followed the step-by-step process outlined below. Guidehouse completed each of the initial activities in the first year of the study, with each subsequent phase including the ongoing activities completed by the team. Phase 1 of this study occurred in 2016 and was a pilot phase to test the data collection and analysis protocols prior to applying them to a full statewide sample, proportionally distributed across PAs. The initial survey

and meter installation period, referred to as Phase 2, occurred between March 2017 and June 2017.

In Phase 3, the team completed the ongoing panel study activities, re-surveyed previous participants, and replenished lost sample points from September 2018 through November 2018. The team repeated this process in Phase 4 (October 2019 through March 2020) and Phase 5 (November 2020 through October 2021), including installing additional data loggers to collect natural gas usage and record space temperature data. Phase 5 also included additional data collection of EV usage. Phase 6 repeated the process but did not include a comprehensive report. Phase 7 repeated the process and included a comprehensive report. For the current phase, Phase 8, meters were removed from the field and only the survey portion of the study continued.

Information for each step is provided below, and Appendix A contains additional details on the study's methodology:

1. **INITIAL: Conduct an online survey** to inventory saturation of several key end uses in Massachusetts residences. The initial survey asked questions related to the respondents' demographics, home characteristics, and home appliances. The team supplemented the general population survey for all PAs by targeting geographies that had a higher saturation of underrepresented priority characteristics such as renter, low income, multifamily, and non-English-speaking households.
2. **ONGOING: Analyze data** to determine statewide saturation, equipment characterizations, and any new research objectives.
3. **ONGOING: Re-survey study participants** to determine what changes they made to the end uses of interest in their home. The Phase 8 follow-up survey received 2,149 completes, with a response rate of 39%. Survey respondents who indicated they purchased new equipment within the past phase were offered an additional incentive to take a picture of their new equipment's nameplate or invoice for characterization. Of the 827 respondents eligible for this survey module, 347 provided additional information on their new equipment.
4. **ONGOING: Replenish lost sample points** to maintain a robust and representative sample of study participants in both the survey-based and onsite data collection samples. The replenishing survey—called the new customer survey throughout this report—aimed to recruit the remaining 4,151 respondents to achieve a total surveyed sample of 6,300 for Phase 8. The team completed the recruitment for this survey via email and postcards and targeted subpopulations that were underrepresented by the follow-up survey respondents.[2] The replenishing survey for Phase 8 was designed to maintain a robust and representative sample by targeting subpopulations that were underrepresented in the follow-up survey, including renters, multifamily households, non-English speakers, and environmental justice communities (EJCs). Post-weighting (using building type, renter/owner status, and income level) was applied to align the sample with population demographics and facilitate valid trend analysis. While these efforts improved representativeness, limitations remain due to low response rates and potential unmeasured sources of bias. The report

[2] The team used email and postcard outreach for customers with valid email addresses in the utility customer population dataset who were not flagged as Do Not Contact. The team used postcard outreach for all remaining customers.

acknowledges these uncertainties and provides additional methodological details and demographic comparisons in Appendix A. In total, the new customer survey received 3,411 completes, with a response rate of 1.5%. Overall, the existing and new customer surveys achieved a total of 5,560 completes, with 4,831 usable completes after initial quality control.

Table 1-1 provides an overview of the key research activities and report deliverables completed across Phases 2 through 8 of the study. Each year, Guidehouse collected and summarized saturation and characterization data for residential buildings in Massachusetts. Electric load shape data was gathered through Phase 7, while gas load shape data was collected during Phases 4 to 7. Updates to TRM values occurred in Phases 2, 3, and 4, with additional updates in Phase 7.[3] Delivered fuels analyses were conducted in Phases 3 and 4, and setpoint and space temperature analyses were performed in Phases 4 and 5. Notably, energy burden questions and an electrification readiness assessment were incorporated into the survey in Phases 7 and 8, expanding the study's focus to include household energy affordability and preparedness for electrification.

Table 1-1. Study Activities by Phase and Year

Research Activities	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Report Year	2019	2020	2021	2022	2023	2025
Saturation and Characterization	X	X	X	X	X	X
Electric Load Shapes	X	X	X*		X	
TRM Values (e.g., EFLH, CF, EUL)	X	X			X	X
Delivered Fuels	X	X			X	
Gas Load Shapes		X	X*		X	
Setpoints and Space Temperature		X	X		X	
EV Consumption and Load Shapes				X	X	
COVID Behavior and Usage Impacts				X	X	
Energy Burden					X	X
Electrification Readiness					X	X

EFLH = equivalent full load hours; CF = coincidence factor; EUL = effective useful life

*In Phase 5, electric load shape updates were limited to new end uses added in Phase 5, including electric cooktops and EV chargers. Other electric and gas end use data was collected through the Phase 5 metering period but was not summarized in the Phase 5 report due to the influence of the COVID-19 pandemic on equipment usage.

Source: Guidehouse analysis

[3] Guidehouse did not update the TRM values in Phases 5 and 6 due to the influence of the COVID-19 pandemic.

1.4 Updates from Previous Phases of the Study

The Phase 2 through Phase 7 studies were completed from 2018 through 2023.[4] The Phase 8 study incorporates the following improvements and updates made since Phase 7:

1. **Transition to Survey-Only Data Collection:** Phase 8 marks a shift from previous years by discontinuing the metering portion of the study. All data collection in Phase 8 was conducted through online surveys.
2. **Expanded Survey Content:** The Phase 8 survey instrument was updated to reflect evolving priorities in energy affordability and decarbonization and remove questions that are no longer of interest or pertaining to the environment in Massachusetts.
3. **Translation of Survey:** The Phase 8 survey instrument and new customer outreach materials were translated to Spanish and Brazilian Portuguese.
4. **Enhanced Demographic Targeting:** Sampling strategies were refined to improve representation among key demographic groups, including EJCs, non-English speakers, renters, and low-income households. This targeted approach supports more equitable program design and evaluation.

1.5 Terminology

Throughout this report, the research results are referenced with various terminology:

- **Saturation:** Proportion of homes in the population that has a given end use.
- **Miscellaneous end uses:** End uses include dehumidifiers, pool pumps, other pumps, primary and secondary TVs and peripherals, and primary computers and peripherals.
- **Building type:** The building types are single-family detached, single-family attached (2-4 units), or multifamily (5-plus units).
- **Number of occupants:** This value specifies the number of permanent residents (adults and children) living in the home.

1.6 Abbreviations

Throughout this report, the team references many abbreviations. Terms are defined as follows and on first use in the text:

- **ACL:** Active customer list
- **ACS:** American Community Survey

[4] Phases 1-4 of this ongoing research were called the *Residential Baseline Study*. The comprehensive reports and appendices are available on the Massachusetts EEAC website, http://ma-eeac.org/studies/residential-program-studies/. Phase 6 did not include a comprehensive report.

- **AFUE:** Annual fuel utilization efficiency
- **BEV:** Battery electric vehicle
- **CEER:** Combined energy efficiency ratio
- **CF:** Coincidence factor
- **DHW:** Domestic hot water
- **DOE:** U.S. Department of Energy
- **DR:** Demand response
- **EEAC:** Energy Efficiency Advisory Council
- **EER:** Energy efficiency ratio
- **EF:** Energy factor
- **EFLH:** Equivalent full load hours
- **EJC:** Environmental justice community
- **EMS:** Energy management system
- **EUL:** Effective useful life
- **EV:** Electric vehicle
- **GW:** Gigawatt
- **HVAC:** Heating, ventilation, and air conditioning
- **HRV/ERV** Heat Recovery Ventilator or Energy Recovery Ventilator systems
- **IMEF:** Integrated modified energy factor
- **kBtu:** One thousand British thermal units
- **kW:** Kilowatt
- **kWh:** Kilowatt-hour
- **MMBtu:** One million British thermal units
- **NEC:** National Electric Code

- **PA:** Program Administrator
- **PHEV:** Plug-in hybrid electric vehicle
- **PUMA:** Public Use Microdata Area
- **PUMS:** Public Use Microdata Sample
- **PV:** Photovoltaic
- **RBUEC:** Residential Building Use and Equipment Characterization
- **SEER:** Seasonal energy efficiency ratio
- **TRM:** Technical Reference Manual
- **UEF:** Uniform energy factor

2. Results and Key Findings

This section contains saturation of key end uses by end use category. It also includes findings on electric vehicles (EVs), energy expenses, heat pumps and electrification readiness. Further end use-specific results are available in Section 3, including additional breakouts of saturation and the characterization of newly installed equipment. The full accompanying datasets, including additional charts and graphics, are provided as Appendix B to this report.

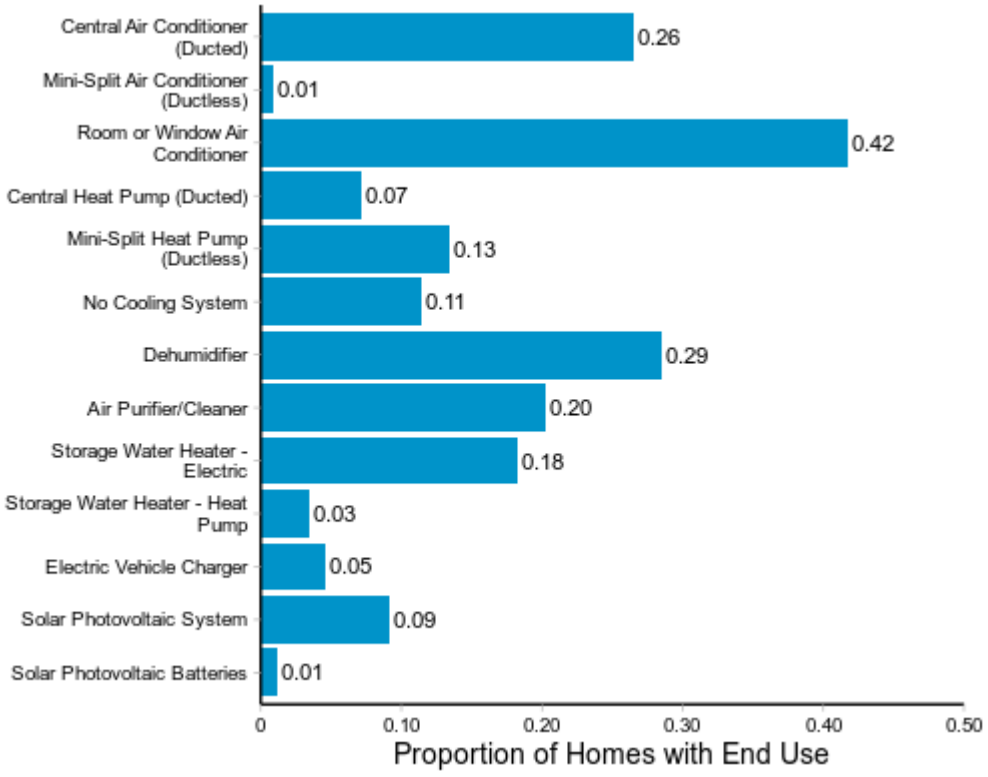
2.1 Saturation of Key End Uses

This section highlights updated statewide saturation for key end uses and notable changes in saturation that have occurred since the previous comprehensive report. For the purposes of this report, saturation is defined as the proportion of homes with the end use in the population. The population is defined as all customer accounts within the PA service territories. The full record of updated saturation and changes in saturation are available in Appendix B.

2.1.1 Saturation of Notable Electric End Uses

Figure 2-1 shows the updated saturation for select end uses.

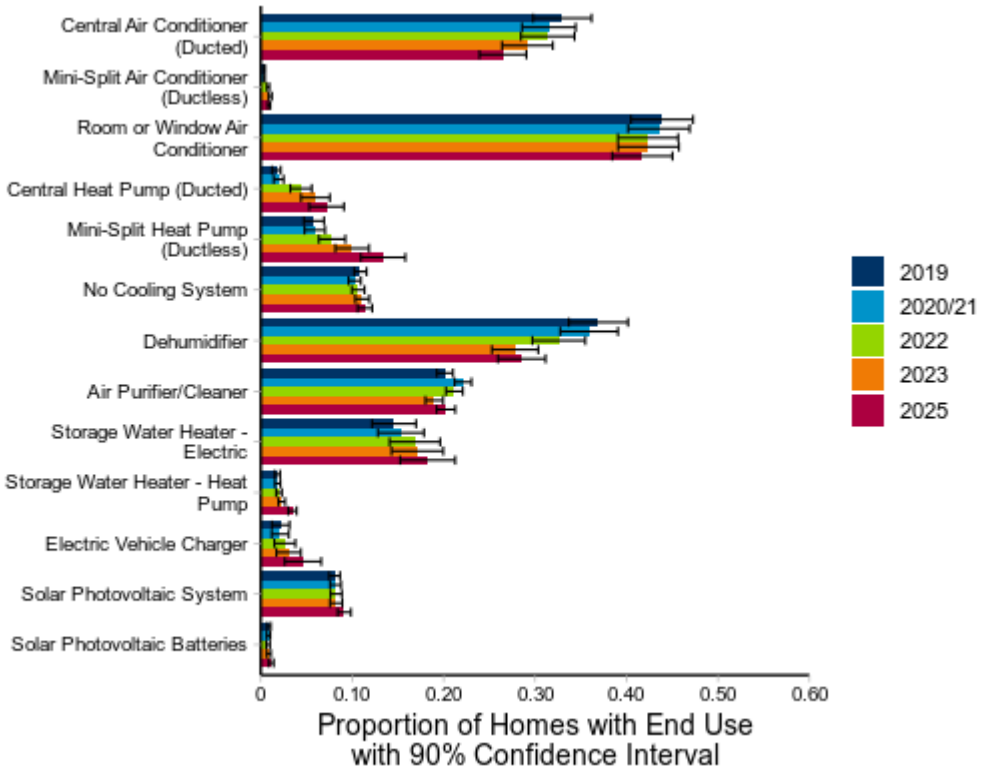
Figure 2-1. 2025 Saturation for Select End Uses



Source: Guidehouse analysis

Figure 2-2 displays the saturation trends for select end uses from 2019 through 2025, along with 90% confidence intervals. Among cooling systems, there has been a decline in central air conditioners and room air conditioners, and a significant increase in both central and mini-split heat pumps. Other notable trends include a decrease in dehumidifiers, an increase in heat pump water heaters and EV chargers, and minimal growth in solar photovoltaic (PV) systems and batteries.

Figure 2-2. Saturation Trends for Select End Uses



Source: Guidehouse analysis

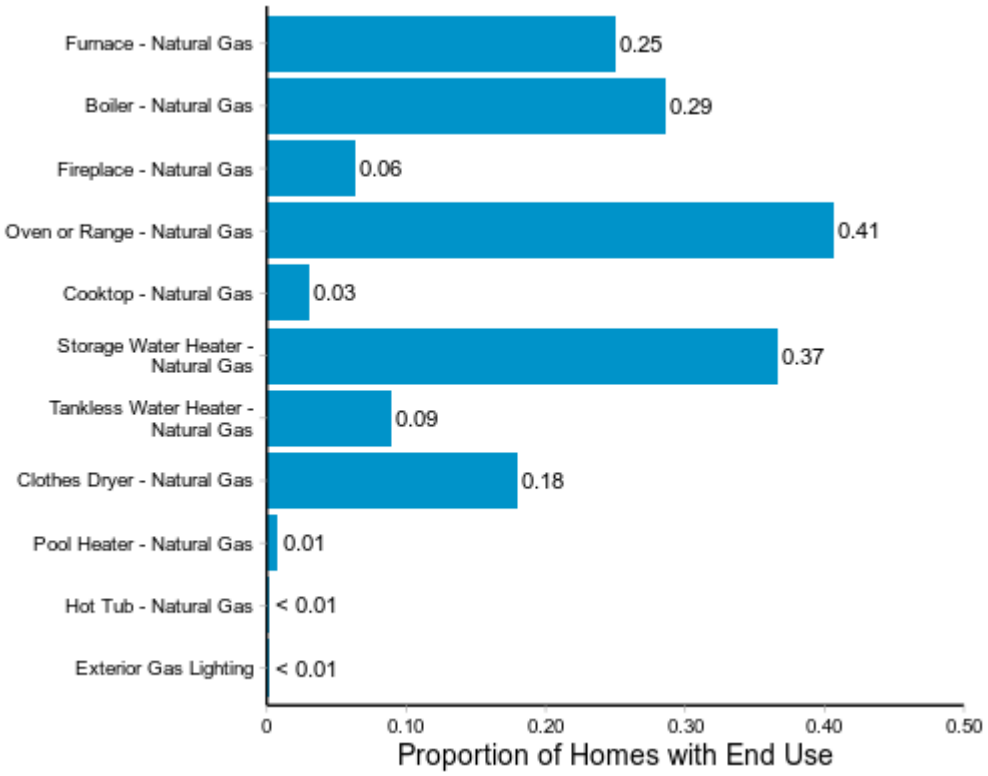
Key Finding: Increased adoption of heat pumps, EV chargers, and other electrification technologies aligns with broader decarbonization trends, though solar PV and battery storage adoption remains limited.

Key Finding: The saturation of dehumidifiers has decreased in recent years.

2.1.2 Saturation of Gas and Oil End Uses

This section includes findings on the saturation of all gas- and oil-specific end uses included in the study. Figure 2-3 shows the current saturation of gas end uses, indicating that natural gas remains a prevalent fuel for heating, water heating, and cooking.

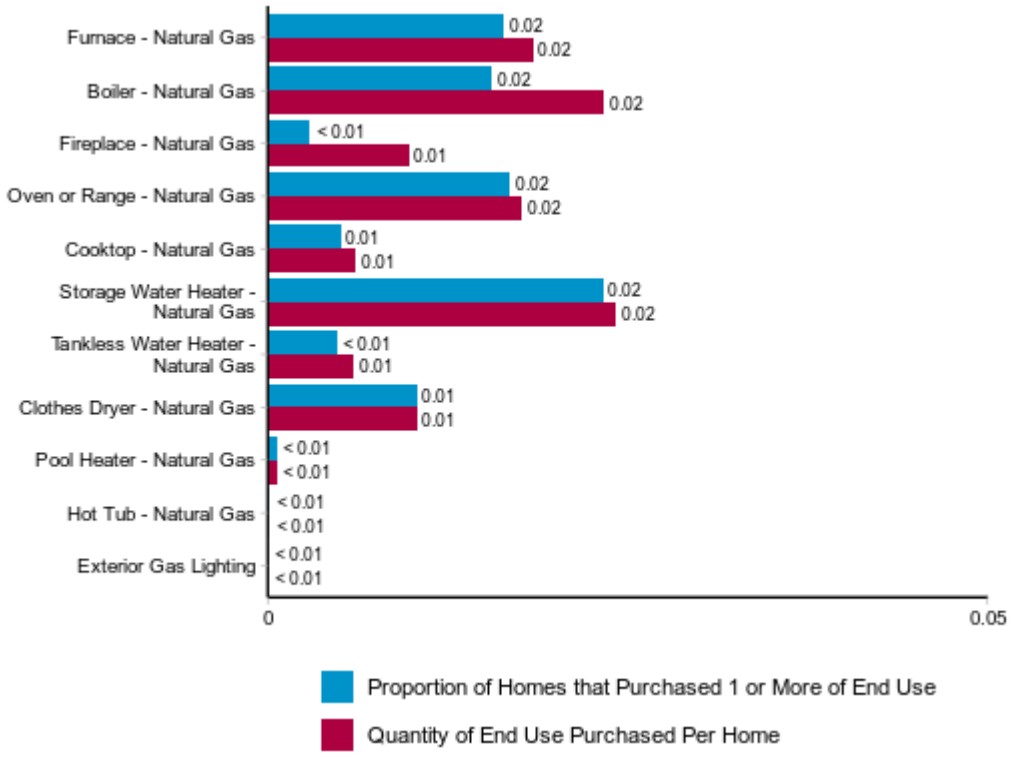
Figure 2-3. Gas End Use Saturation



Source: Guidehouse analysis

Figure 2-4 shows the number of homes that purchased new gas equipment in the past year. Common gas end uses—furnaces, boilers, water heaters, and ovens/ranges—showed approximately 2% each. These findings indicate that purchases are concentrated in core heating and cooking appliances, which represent key opportunities for electrification programs.

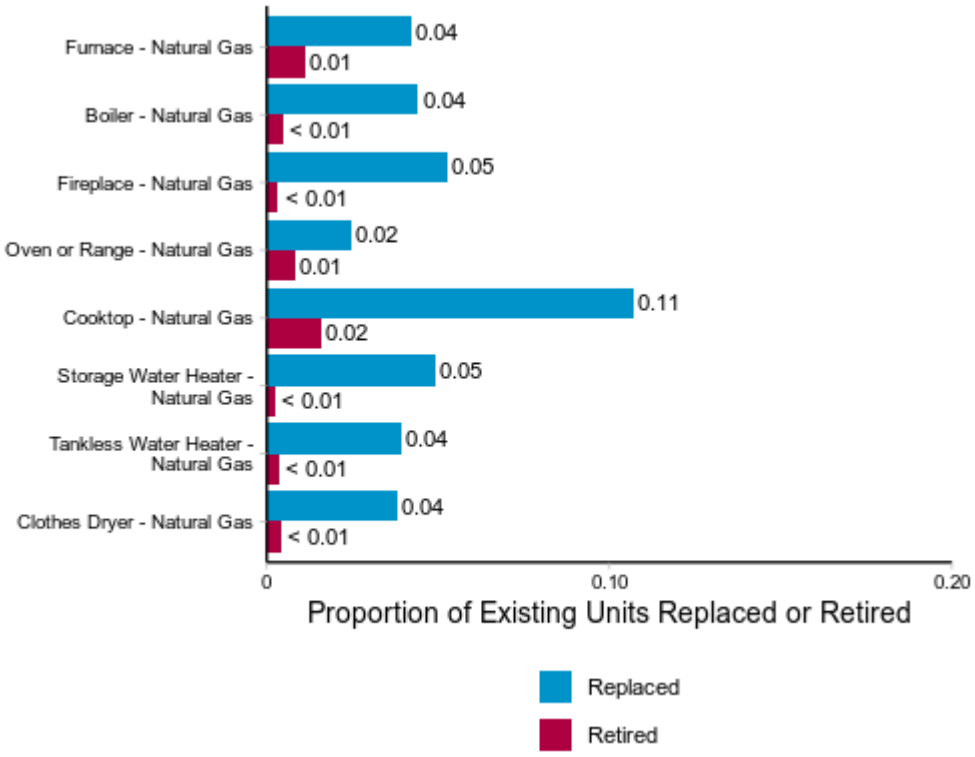
Figure 2-4. Proportion of Homes that Purchased Gas End Uses in the Past Year



Source: Guidehouse analysis

Figure 2-5 shows the proportions of existing gas units replaced or retired in Massachusetts in the past year. Replacement activity is significantly more common than retirement across all end uses, suggesting that most households that currently have gas end uses are keeping them upon replacement rather than opting for an electric alternative.

Figure 2-5. Proportion of Existing Gas Units Replaced or Retired in the Past Year



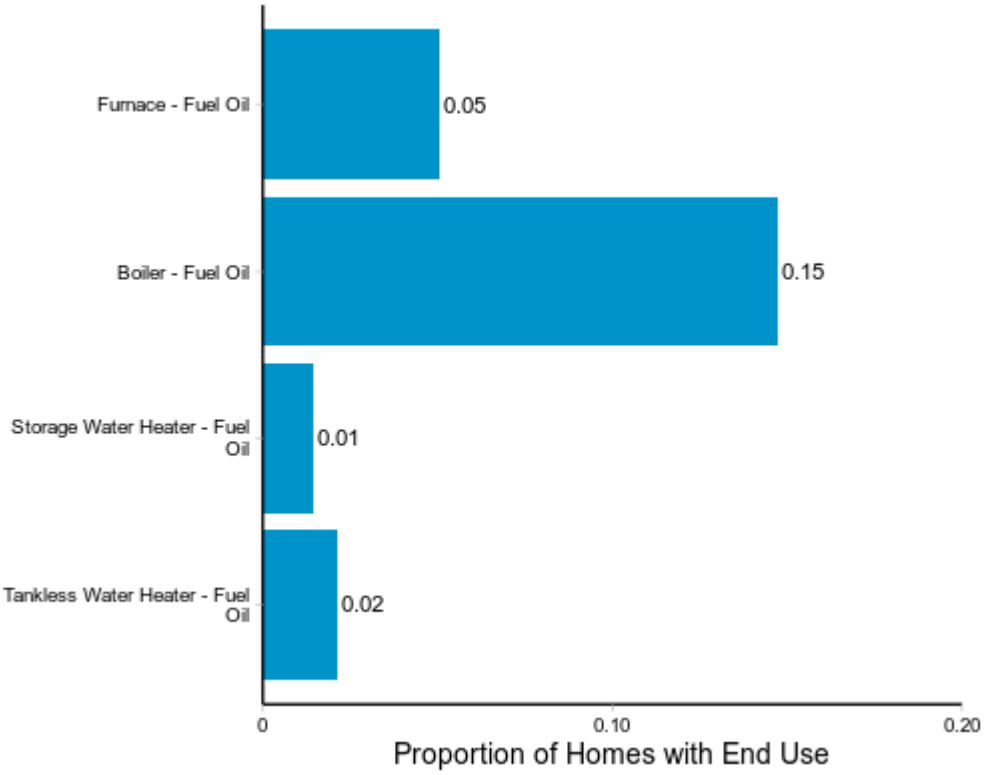
*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Key Finding: Replacement rates for natural gas boilers, furnaces, and water heaters are all similarly low, indicating the need for additional incentives to encourage early retirement as part of electrification initiatives.

Figure 2-6 shows the prevalence of fuel oil-based equipment in homes. While less common than gas, fuel oil heating systems still account for a sizeable proportion of the population, though fuel oil water heaters are less common.

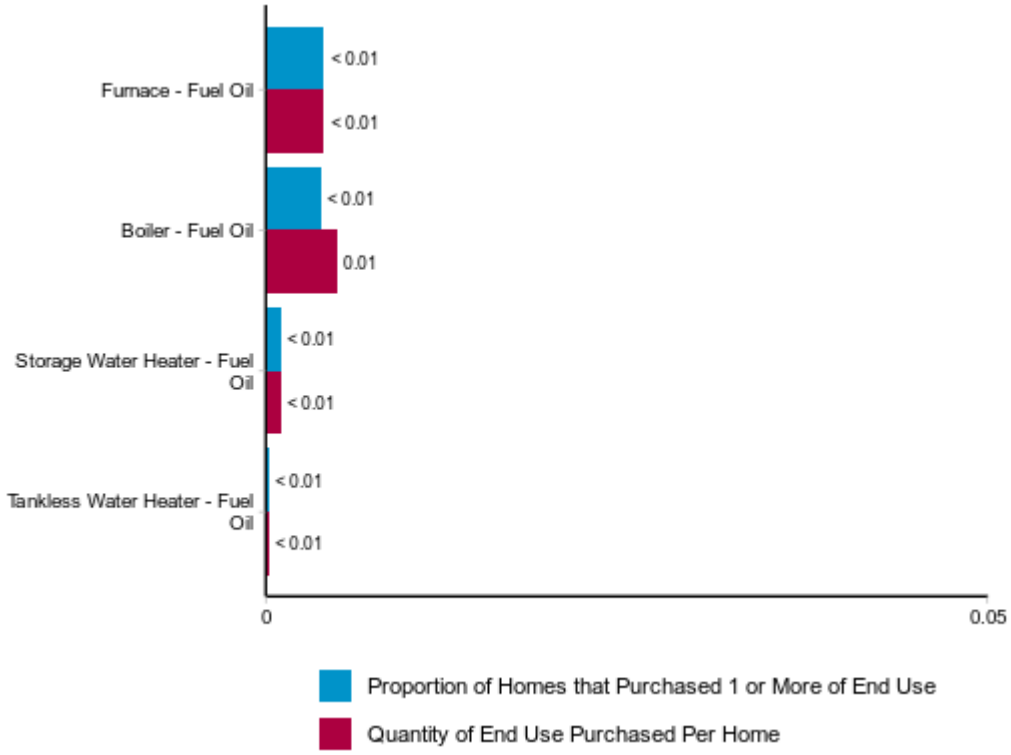
Figure 2-6. Oil End use Saturation



Source: Guidehouse analysis

Figure 2-7 shows that purchases of fuel oil equipment are extremely rare, with all categories—furnaces, boilers, storage water heaters, and tankless water heaters—recording purchase rates below 1%.

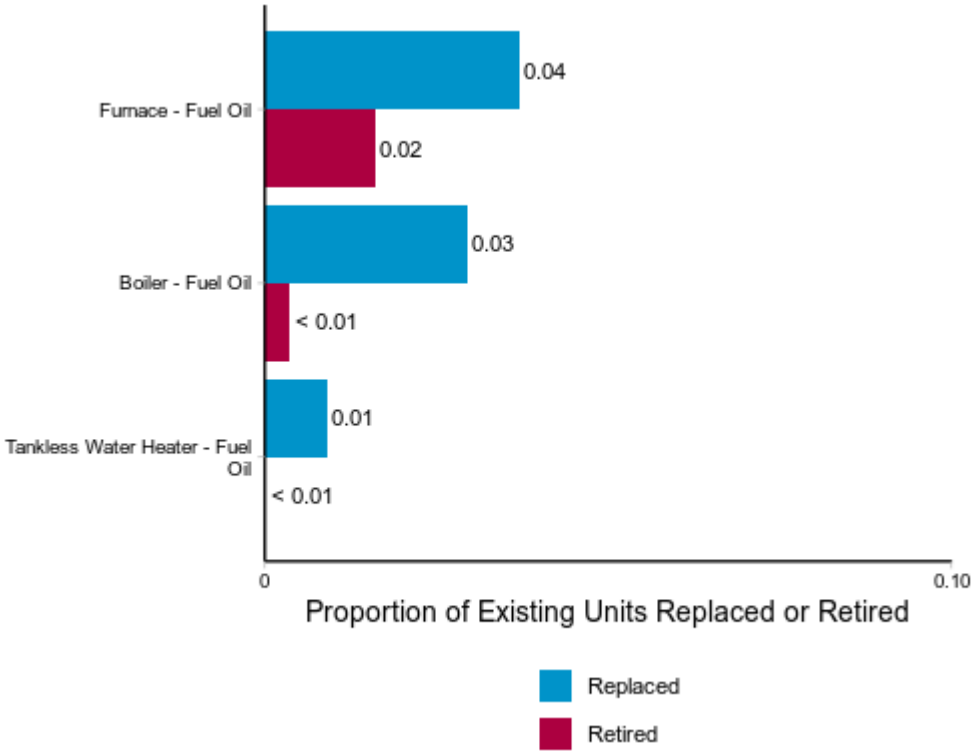
Figure 2-7. Proportion of Homes that Purchased Fuel Oil End Uses in the Past Year



Source: Guidehouse analysis

Figure 2-8. shows the proportion of existing fuel oil units that were either replaced or retired. All fuel oil end uses had low replacement and retirement rates.

Figure 2-8. Proportion of Existing Oil Units Replaced or Retired in the Past Year



*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

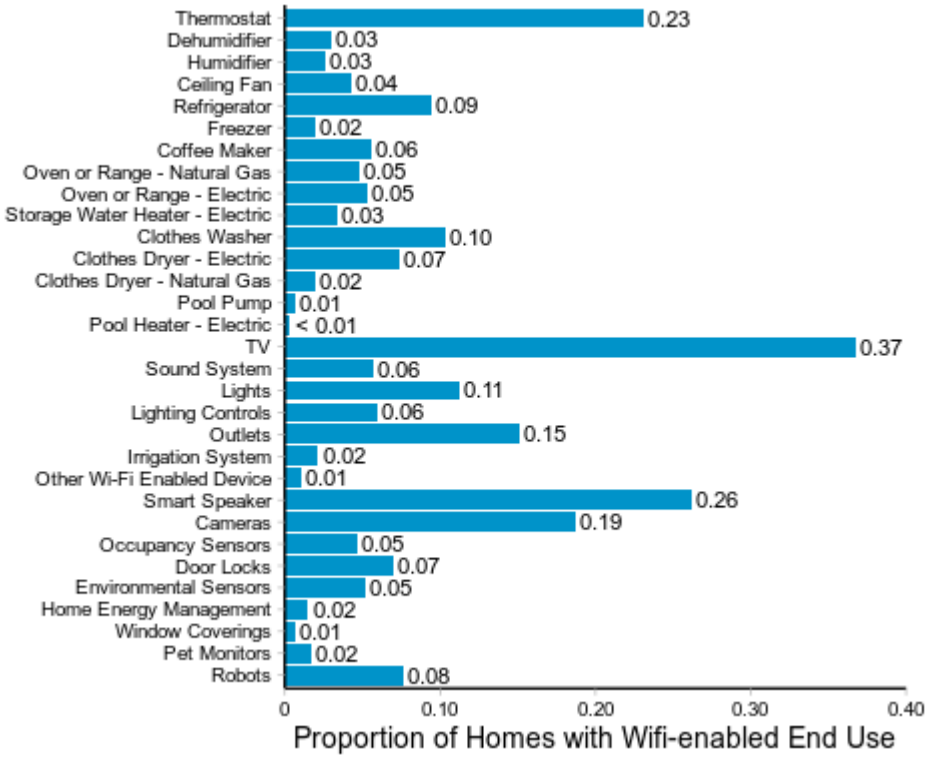
Key Finding: Approximately 1% of homes purchase new oil furnaces or boilers each year, reinforcing the opportunity to promote full electrification during heating system replacement.

Key Finding: 20% of Massachusetts homes still rely on oil boilers or furnaces for heating, representing a prime opportunity for targeted heat pump adoption and electrification efforts that might be more cost-effective than for homes heating with natural gas.

2.1.3 Saturation of Internet-Connected End Uses

Figure 2-9 shows the prevalence of Wi-Fi-enabled devices and appliances in homes, which can help to inform the potential for DR programs to shift peak electric loads. Smart thermostats are present in nearly a quarter homes, indicating significant potential to shift heating and cooling loads. Connected clothes dryers are less prevalent (~7%) but still offer significant opportunity as schedulable, deferrable loads that can be shifted away from peak periods—particularly effective when paired with user prompts or automated DR events. Wi-Fi–enabled electric water heaters are even rarer (~3%)—increased adoption would make them a valuable DR resource due to providing meaningful thermal storage potential and options for pre-heating and timed recovery.

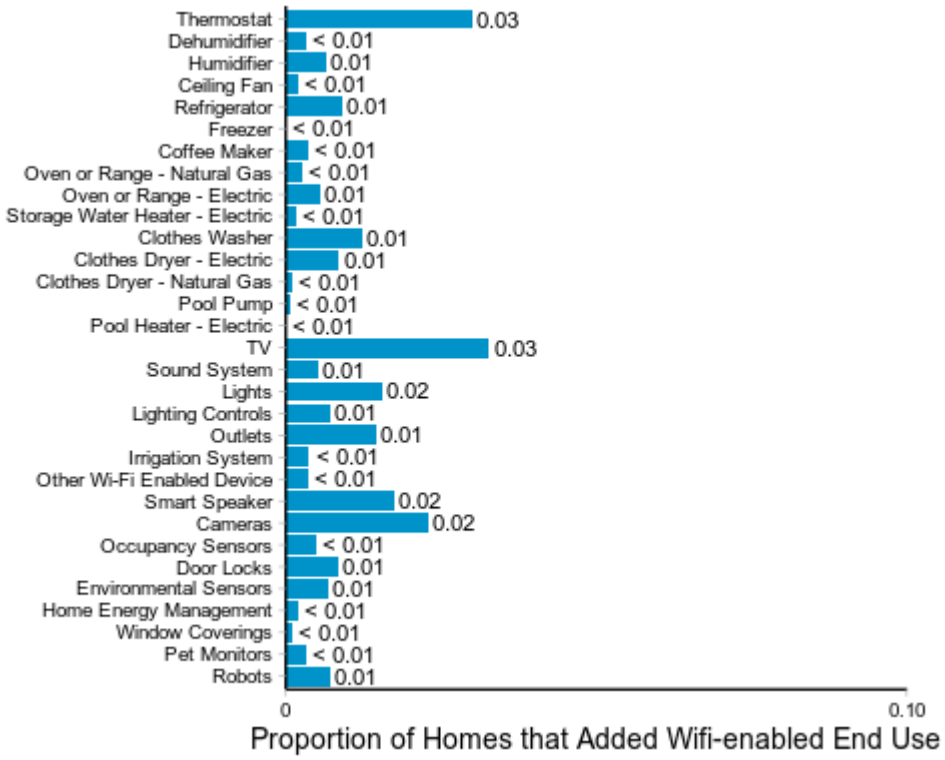
Figure 2-9. Saturation of Internet-Connected End Uses



Source: Guidehouse analysis

Figure 2-10. illustrates the share of homes that added Wi-Fi-enabled devices or appliances. TVs and smart thermostats were the most common additions, followed by cameras, smart speakers, and lights.

Figure 2-10. Proportion of Homes that Added Internet-Connected Equipment in the Past Year



Source: Guidehouse analysis

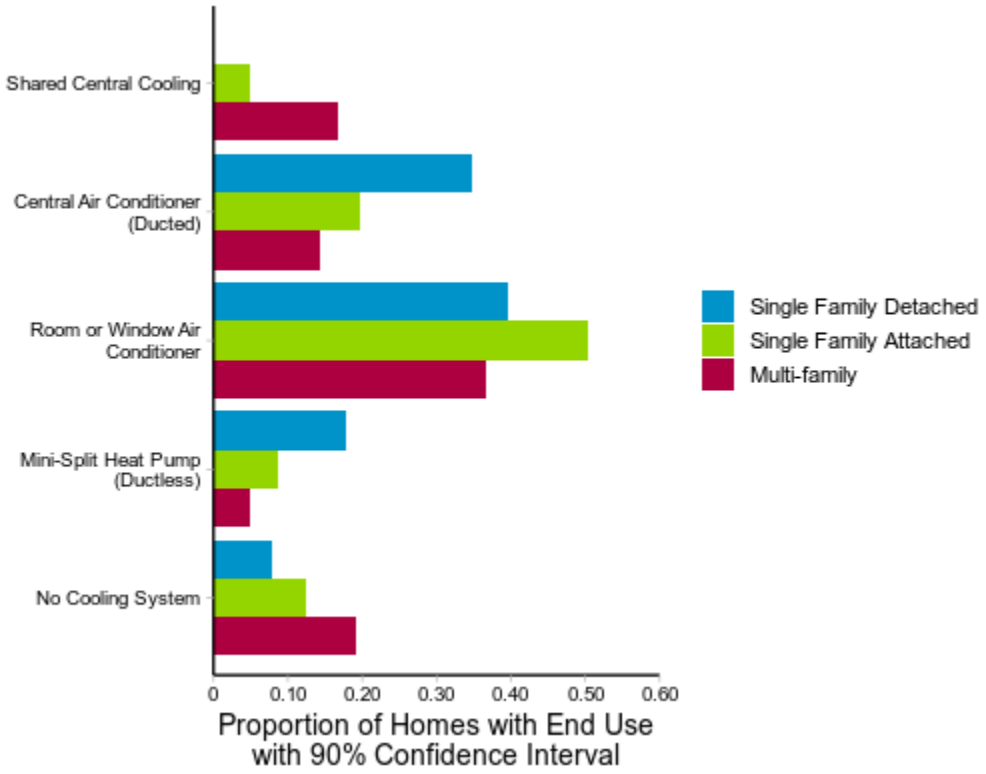
Key Finding: The data suggests that Wi-Fi-enabled devices are primarily concentrated in entertainment (TVs, smart speakers) and climate control (thermostats), with security (cameras) also gaining traction. However, energy-focused devices such as home energy management systems (EMSs) and smart appliances show minimal adoption.

2.1.4 Saturation Differences by Building Type

This section highlights notable end uses for which the saturation varies significantly by building type. Full saturation results split by building type and other demographic variables are available in Appendix B.

Figure 2-11 shows cooling end use saturation differences by building type. Central air conditioners and mini-split heat pumps are most common in single-family detached homes, while room air conditioners are more prevalent in single-family attached homes. Multifamily homes have higher rates of shared cooling systems or no cooling system at all.

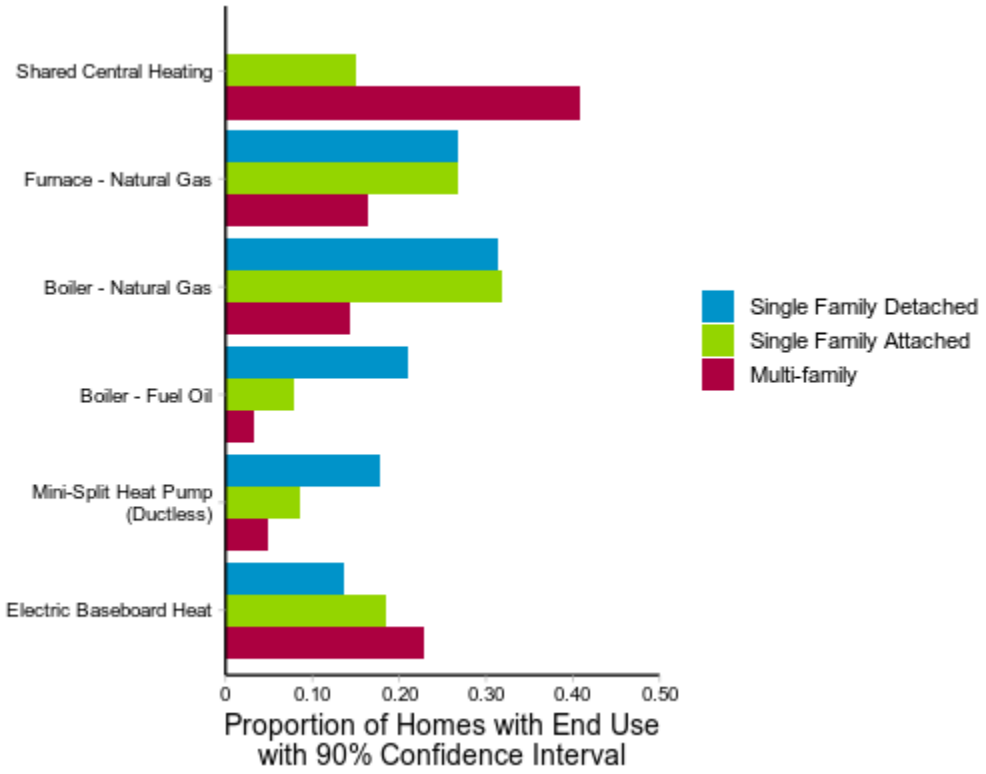
Figure 2-11. Notable Cooling Saturation Differences by Building Type



Source: Guidehouse analysis

Figure 2-12 shows differences in heating saturations by building type. Fuel oil boilers and mini-split heat pumps have higher saturations in single-family detached homes, while natural gas furnaces and boilers are similarly prevalent in single-family attached and detached homes. Shared central heating and electric baseboard heat are more prevalent in multifamily homes.

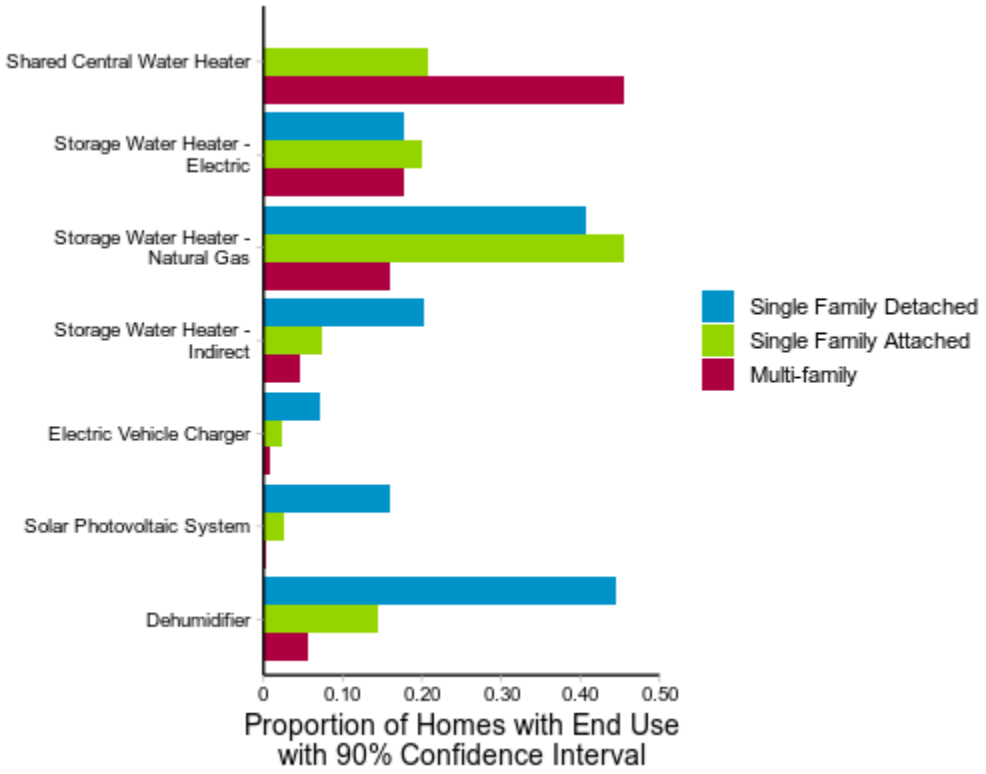
Figure 2-12. Notable Heating Saturation Differences by Building Type



Source: Guidehouse analysis

Figure 2-13 shows saturation differences by building type for hot water and select other end uses. Rates of electric water heaters are similar across building types, while natural gas water heaters are less common in multifamily homes. Indirect water heaters are found most in single-family detached homes, and shared water heaters are most prevalent in multifamily homes. EV chargers, solar PV systems, and dehumidifiers are mostly present in single-family detached homes.

Figure 2-13. Notable Other Saturation Differences by Building Type

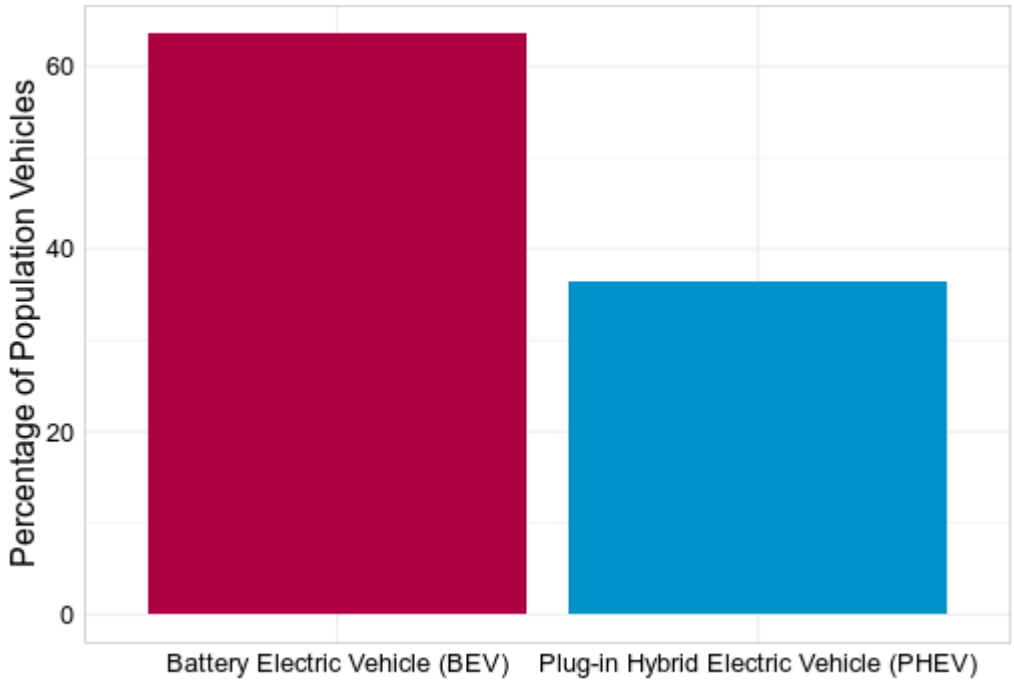


Source: Guidehouse analysis

2.2 Electric Vehicle Characteristics

In total, 6% of homes indicated having an EV, with roughly 4% of homes having a battery electric vehicle (BEV) and the remaining 2% having a plug-in hybrid electric vehicle (PHEV). Figure 2-14 shows the proportion of EV types within the population.

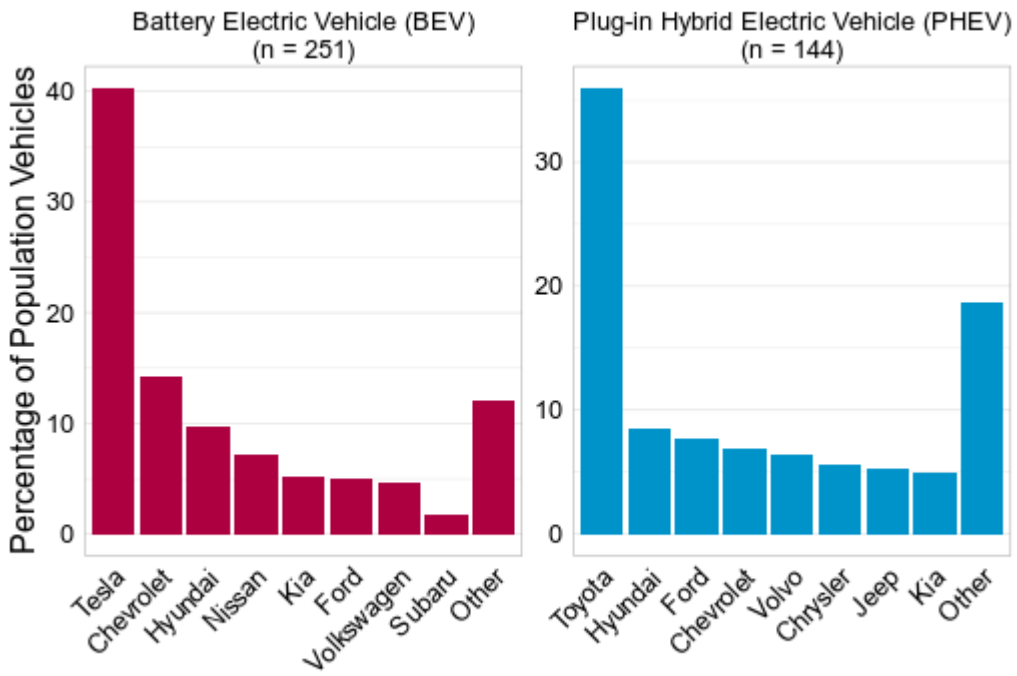
Figure 2-14. EV Types



Source: Guidehouse analysis

Figure 2-15. presents the percentages of each EV type by manufacturer. Tesla has the largest share of the BEV market, while Toyota is the most significant PHEV manufacturer.

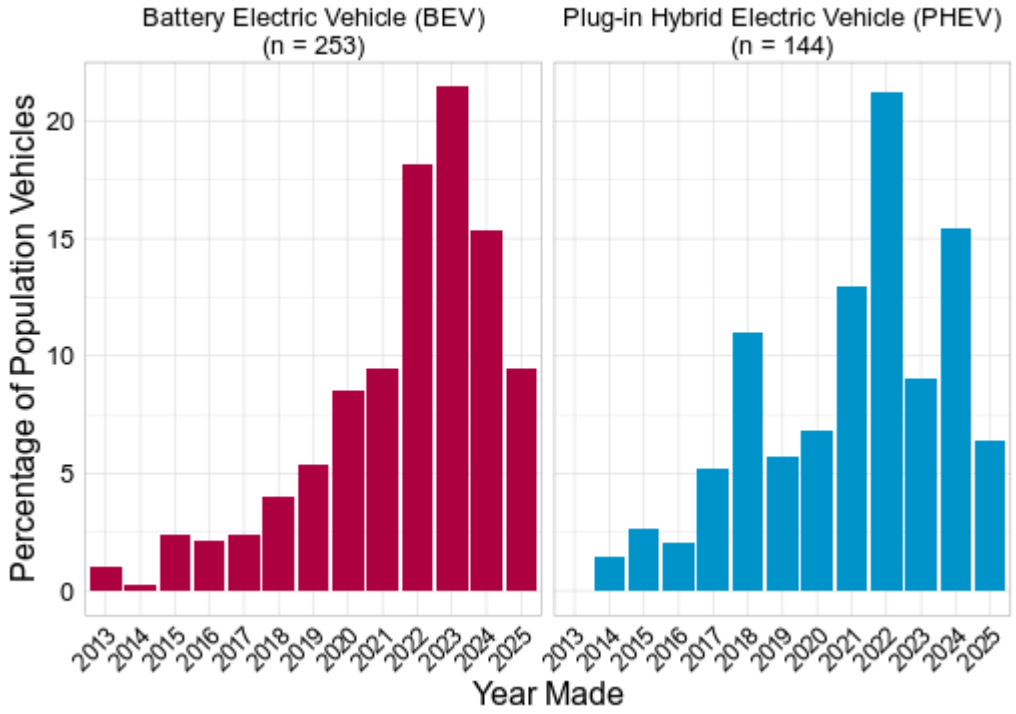
Figure 2-15. EV Manufacturers



Source: Guidehouse analysis

Figure 2-16 shows the year of manufacture of EVs in the population. The majority of both BEVs and PHEVs were manufactured in the past 4 years, which is consistent with the increased saturation of EVs in recent years.

Figure 2-16. EV Years of Manufacture[5]

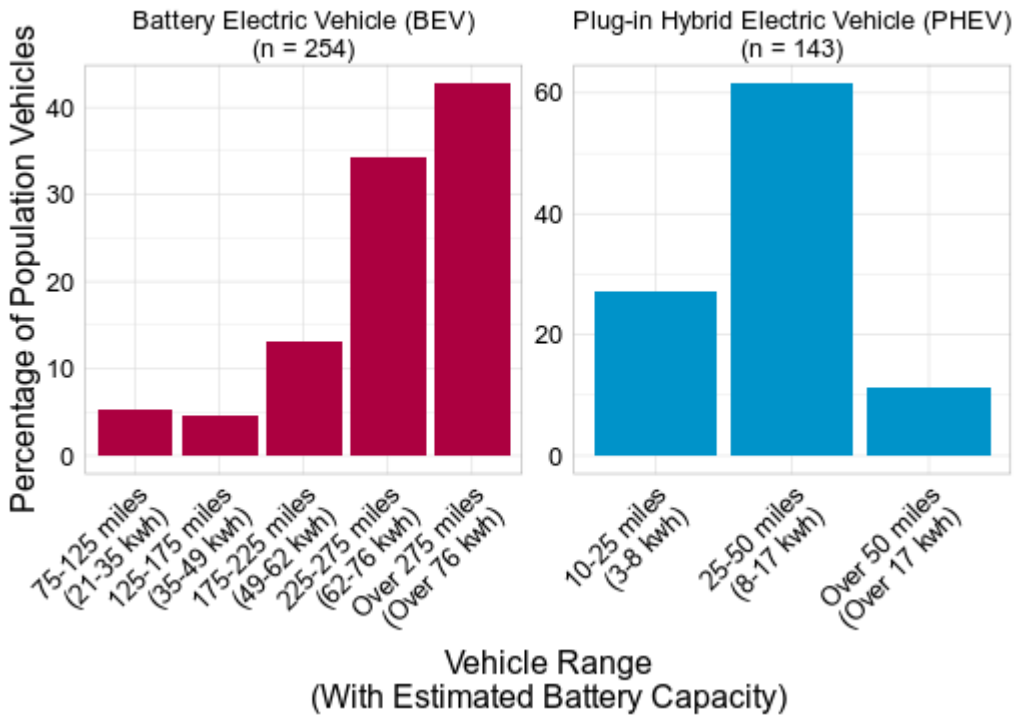


Source: Guidehouse analysis

[5] The survey was fielded in mid-2025, so the numbers for that year are lower due to being only a partial year's worth of data.

Figure 2-17 shows the distribution of self-reported range by EV type, along with associated estimates of vehicle battery capacity (kWh). A significant majority of BEVs are at the higher end of the range (at least 225 miles), likely reflecting both the improvement in battery technology as a whole and an increased consumer preference for EVs capable of making longer trips.

Figure 2-17. Self-Reported EV Range[6]

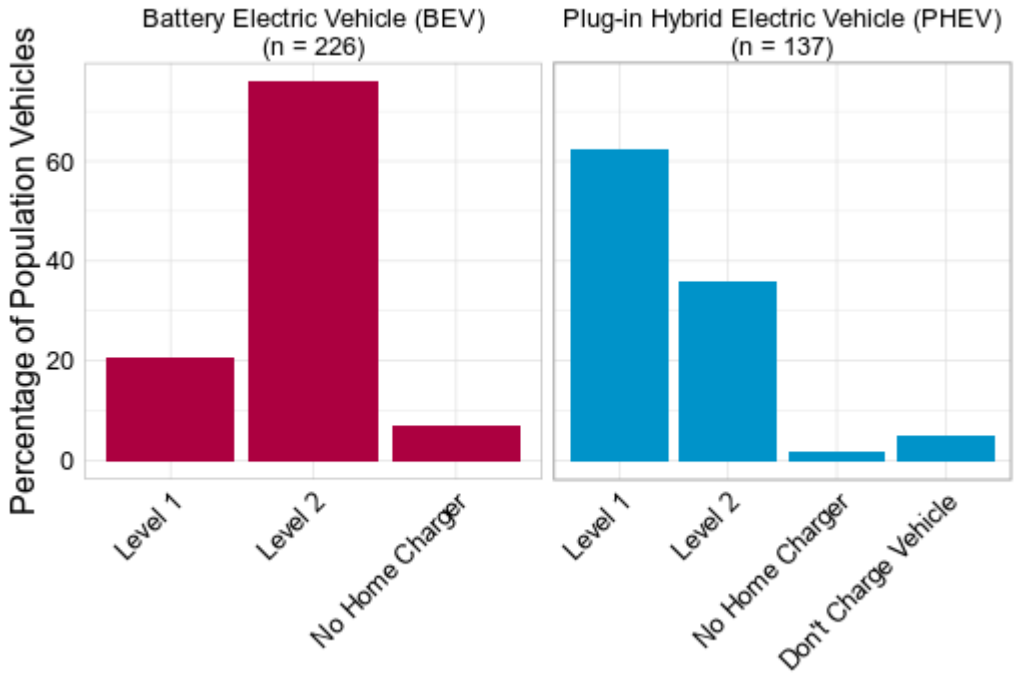


Source: Guidehouse analysis

[6] Self-reported vehicle range was converted to estimated battery capacity using a conversion of 3.60 miles/kWh for BEVs and 3.03 miles/kWh for PHEVs, based on Alternative Fuels Data Center: Data Sources and Assumptions for the Electricity Sources and Fuel-Cycle Emissions Tool

Figure 2-18 shows the distribution of home EV charger types used by owners of BEVs and PHEVs.[7] A significant majority of BEV owners have faster Level 2 chargers, while PHEV owners are more likely to use a Level 1 charger at home, which reflects the smaller batteries and less significant charging needs of PHEVs. A small share (~5%) of both BEV and PHEV owners report having no home charger, suggesting reliance on public or workplace charging infrastructure.

Figure 2-18. Home EV Charger Type

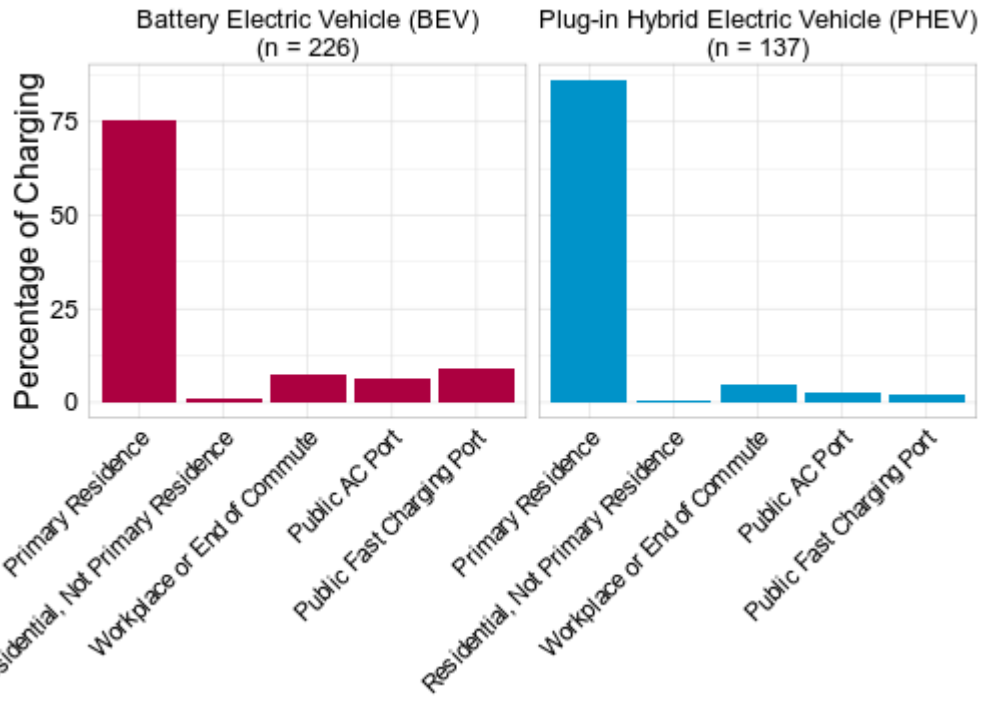


Source: Guidehouse analysis

[7] Some customers indicated having both a Level 1 charger and a Level 2 charger, which explains why the totals sum to greater than 100%.

Figure 2-19 shows the self-reported distributions of charging by location. Charging overwhelmingly takes place at the primary residence for both EV types, though it is an even higher proportion for PHEVs than for BEVs. The remainder of charging is fairly evenly split between workplace/end of commute, public AC ports, and public fast charging ports.

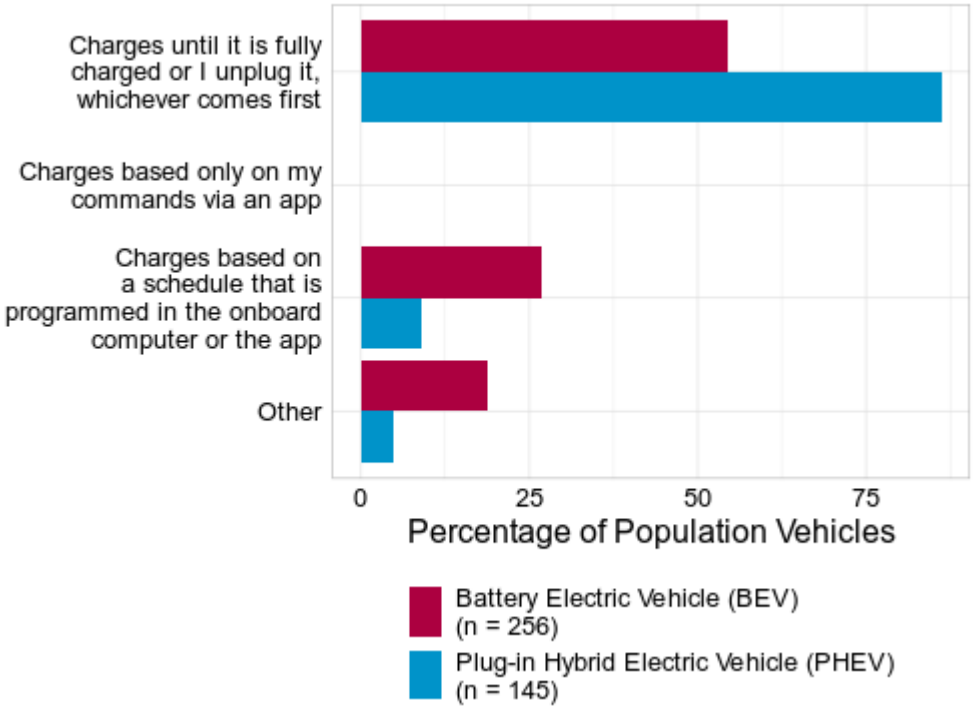
Figure 2-19. Self-Reported Percentage of EV Charging by Location



Source: Guidehouse analysis

Figure 2-20 illustrates the distribution of charging behaviors among BEV and PHEV owners. In most cases, charging occurred without a set schedule, though there is limited adoption of managed charging via a programmed charging schedule, particularly for BEV owners.

Figure 2-20. Self-Reported EV Charging Behavior

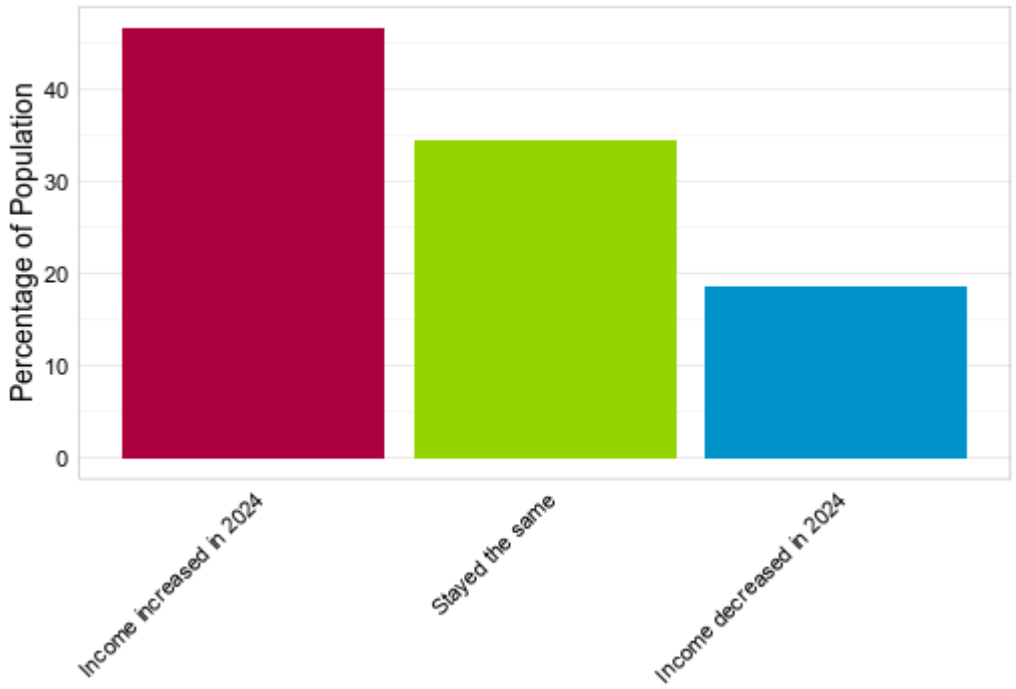


Source: Guidehouse analysis

2.3 Income vs. Energy Expenditures

This section explores changes in income, the financial burden of energy bills, and the ways in which customers have changed their behavior to try to reduce this burden. Figure 2-21 illustrates how household income changed in the population in 2024. Most of the population's income increased or stayed the same in 2024.

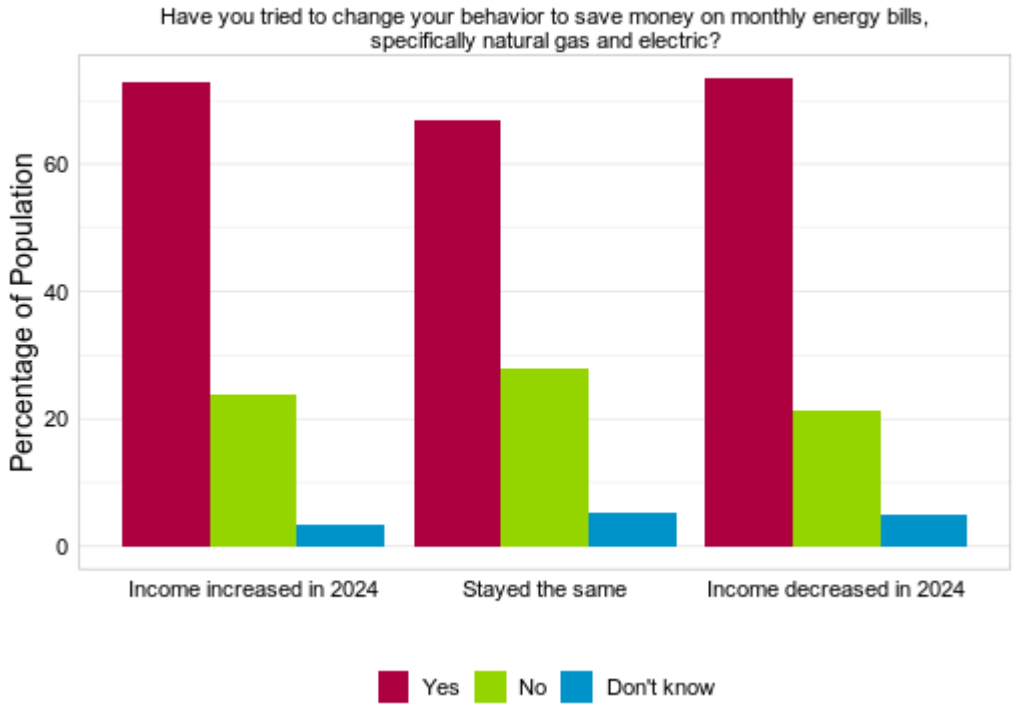
Figure 2-21. Income Changes in 2024



Source: Guidehouse analysis

Figure 2-22 shows the proportion of customers that reported having tried to change their behavior to save money on energy bills. Interestingly, this behavior was as prevalent for those who reported an increase in income as for those who reported a decrease.

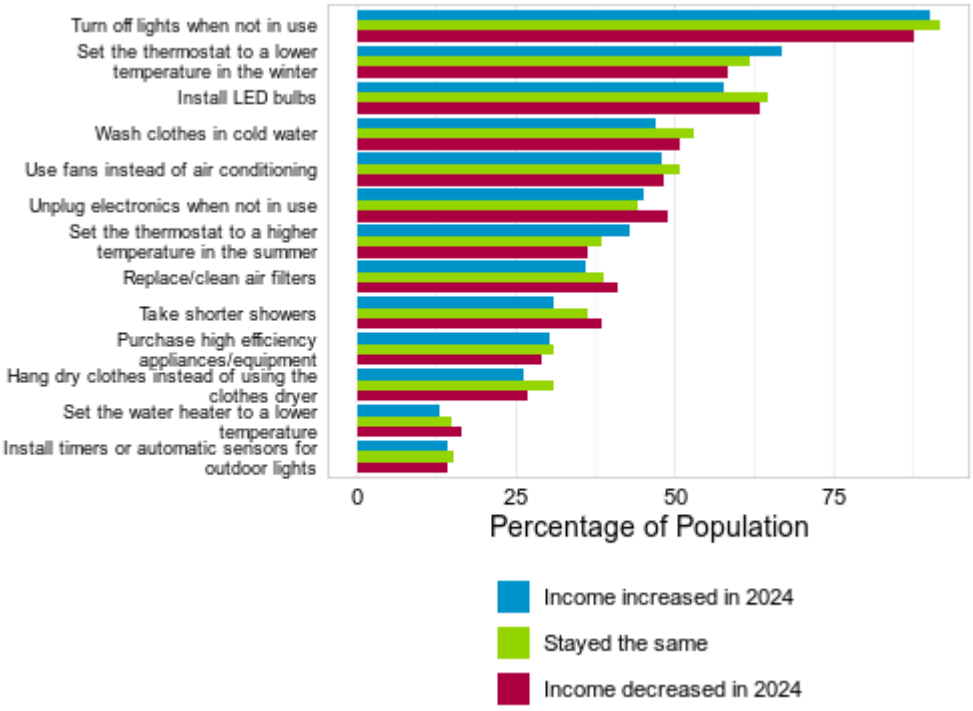
Figure 2-22. Behavior Changes to Save on Energy Bills



Source: Guidehouse analysis

Figure 2-23 shows the percentage of the population that took various actions to try to save money on energy bills, grouped by their income change in the past year. The prevalence of the different actions did not vary much by group, with the most common being turning off lights when not in use, lowering their thermostat setpoint in the winter, and switching to LED light bulbs.

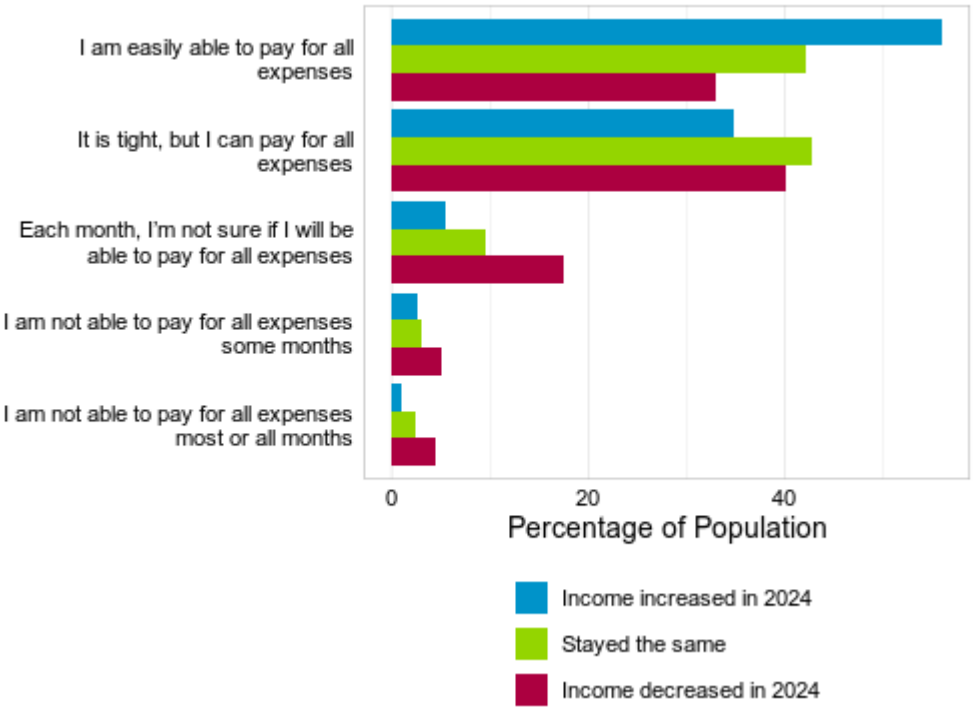
Figure 2-23. Energy Consumption Behavior Changes



Source: Guidehouse analysis

Figure 2-24 shows customers' ability to pay for all household expenses, grouped by change in income in the past year. Roughly a quarter of customers whose income decreased in 2024 were either unable to pay for all expenses or unsure about their ability to do so.

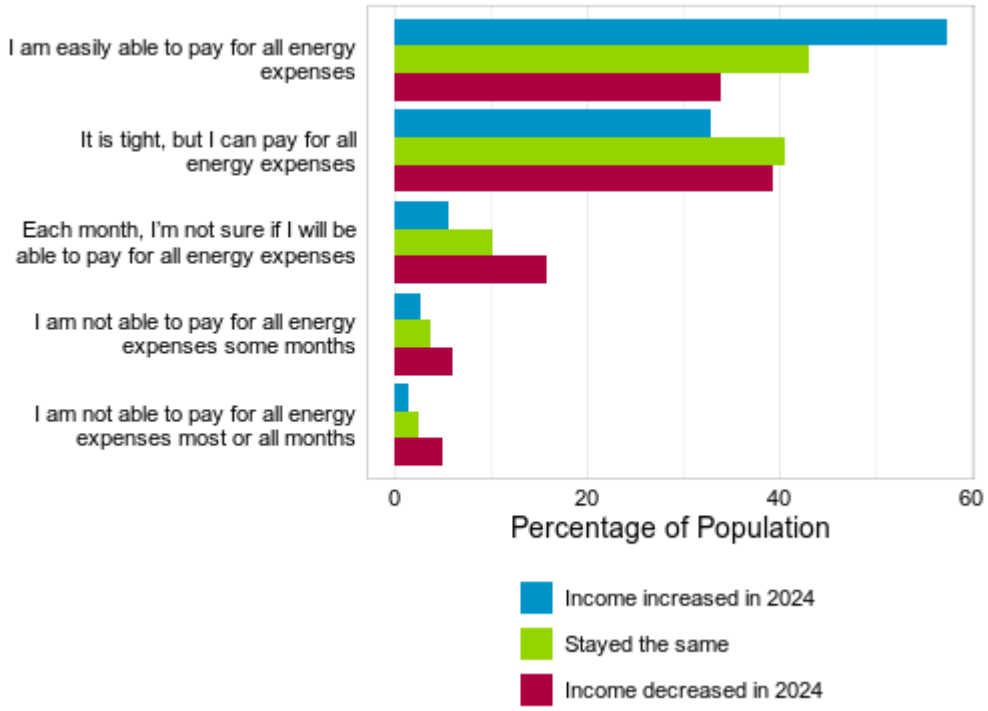
Figure 2-24. Customer Ability to Pay for Household General Expenses



Source: Guidehouse analysis

Figure 2-25 shows customers' ability to pay just energy expenses, grouped by change in income in the past year. As with household expenses, customers whose income decreased in 2024 were more likely to be unable to pay for all energy expenses or unsure about their ability to do so.

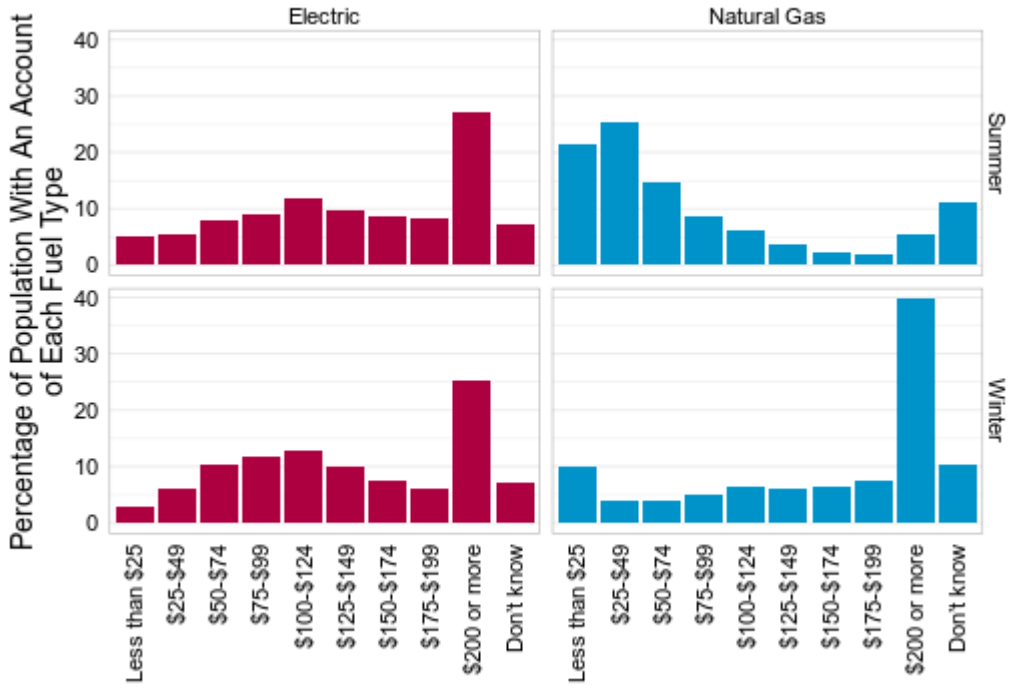
Figure 2-25. Customer Ability to Pay for Household Energy Expenses



Source: Guidehouse analysis

Figure 2-26 shows the distribution of self-reported monthly energy bills by fuel type (electric and natural gas) across summer and winter seasons. Electric bills are fairly consistent across the two seasons but also fairly high, with roughly 25% of accounts reporting bills of $200 or more. Natural gas bills, as expected, show a dramatic seasonal shift: In winter, more than one-third of customers report bills of $200 or more, while in summer, bills are fairly low.

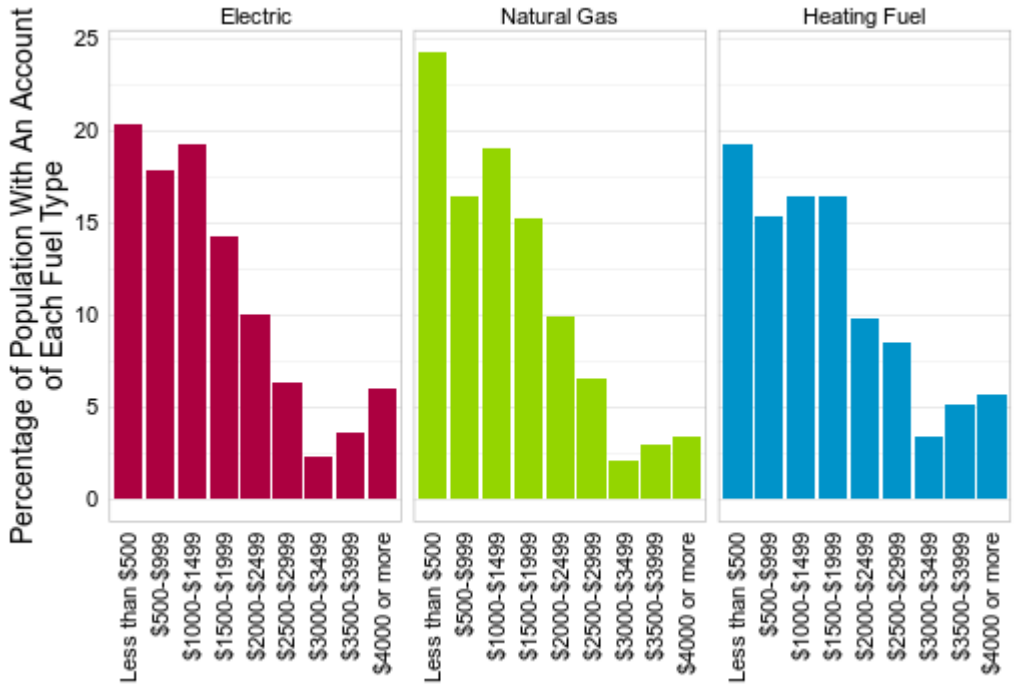
Figure 2-26. Monthly Energy Bills by Fuel Type and Season



Source: Guidehouse analysis

Figure 2-27 shows the distribution of self-reported total annual energy expenses by fuel type (electric, natural gas, and heating fuel). Heating fuel has the highest proportion of bills at the high end of the range, while natural gas bills are at the lower end.

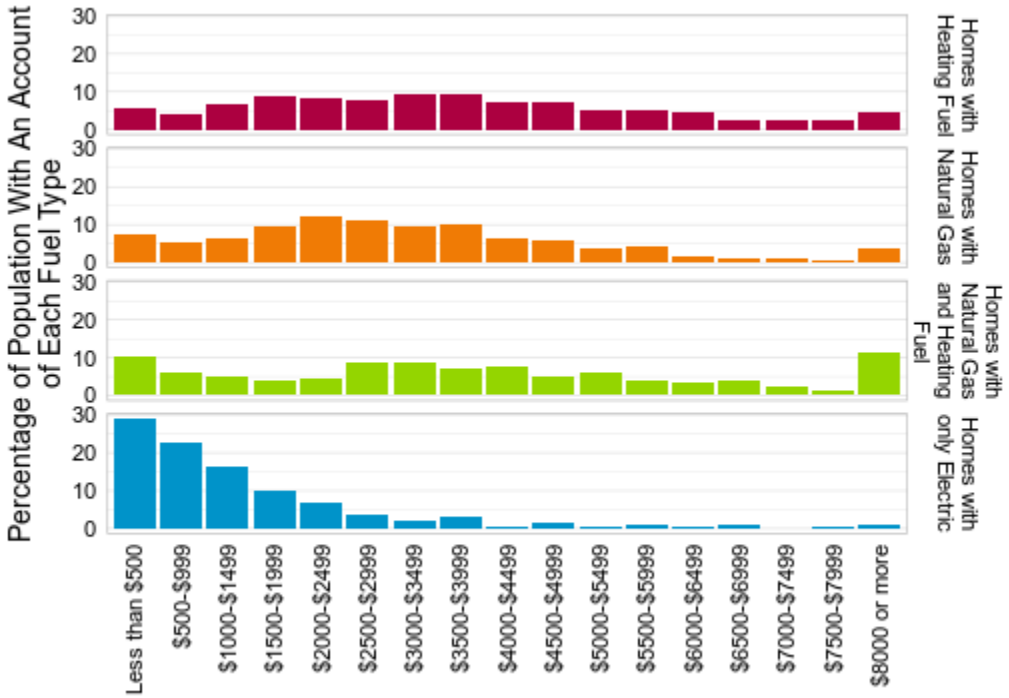
Figure 2-27. Annual Energy Bills by Fuel Type



Source: Guidehouse analysis

Figure 2-28. shows the distribution of total annual bills, summed across all fuel types present in the home. Homes with natural gas and heating fuel had the highest bills on average, followed by homes with heating fuel and then those with natural gas. Homes with only electric service had the lowest bills, though this is likely due to those homes being smaller on average.

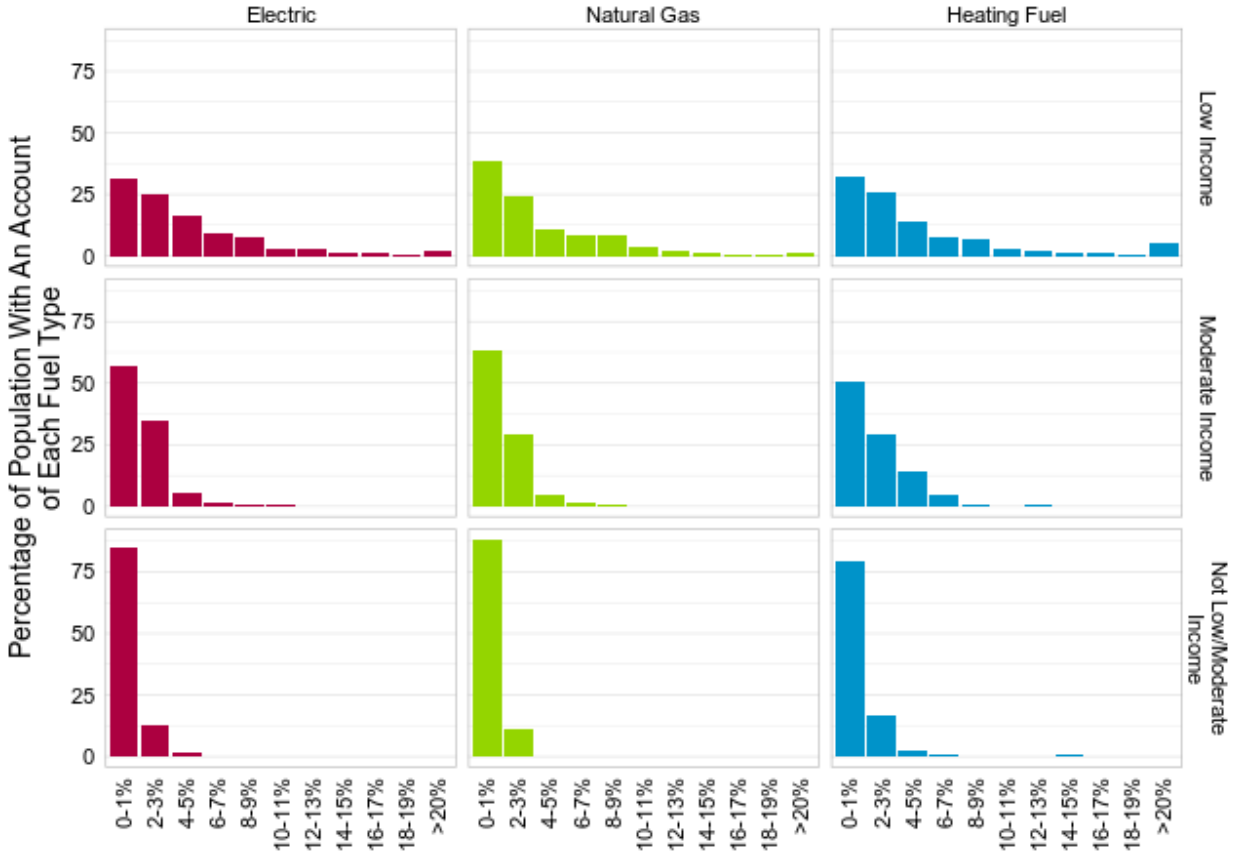
Figure 2-28. Total Annual Energy Bills by Fuel Types in Home



Source: Guidehouse analysis

Figure 2-29 shows annual energy bills as a percentage of income, broken out by income level and fuel type.

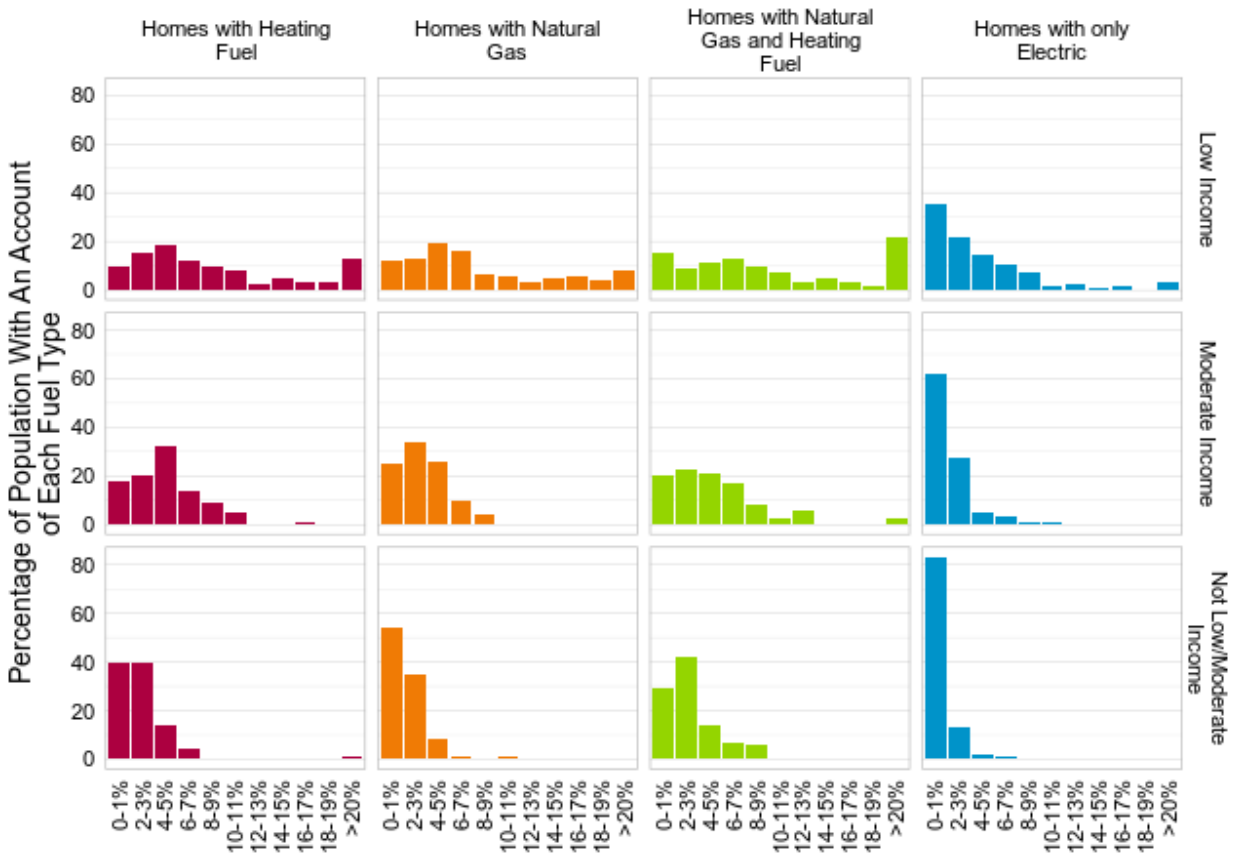
Figure 2-29. Annual Energy Bills as a Percentage of Income by Fuel Type



Source: Guidehouse analysis

Figure 2-30 shows the distribution of total annual energy bills as a percentage of income, summed across all fuel types present in the home. For low-income households, energy costs represent a significant burden, with a meaningful percentage of homes paying 10%-20+% of their total income on energy bills.

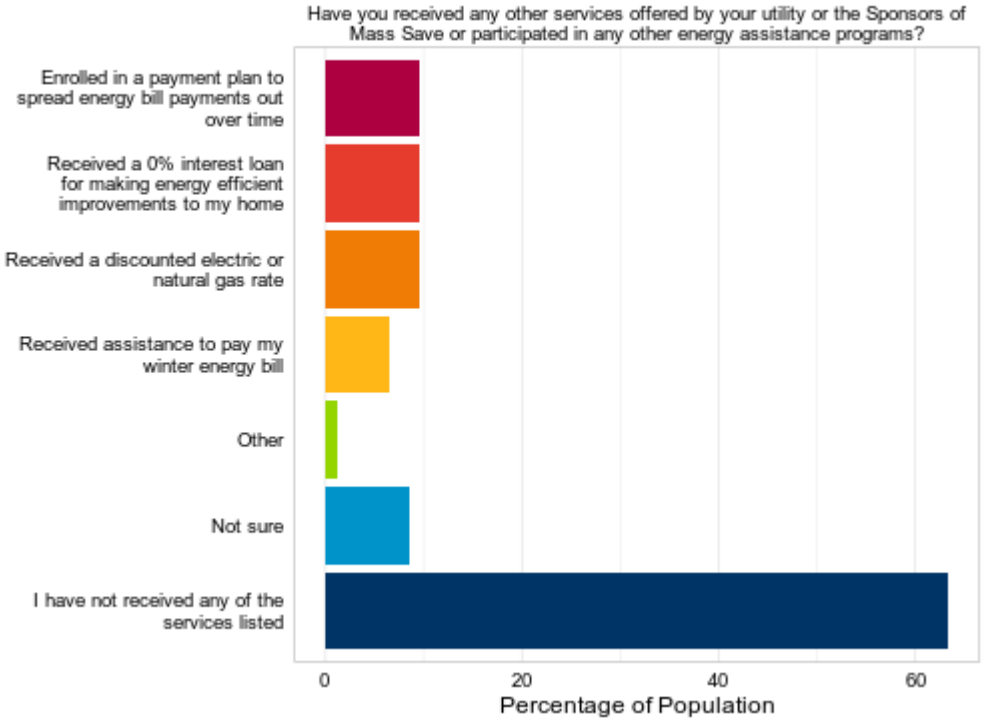
Figure 2-30. Annual Energy Bills as a Percentage of Income for All Fuel Types in Home



Source: Guidehouse analysis

Figure 2-31 shows the percentage of the population who has received various energy assistance services or participated in programs offered by utilities or Mass Save. Nearly two-thirds of respondents indicated that they have not received any of the listed services. Among those who have participated, the most common services include receiving a discounted electric or natural gas rate, enrolling in a payment plan to spread energy bill payments, and receiving assistance to pay winter energy bills.

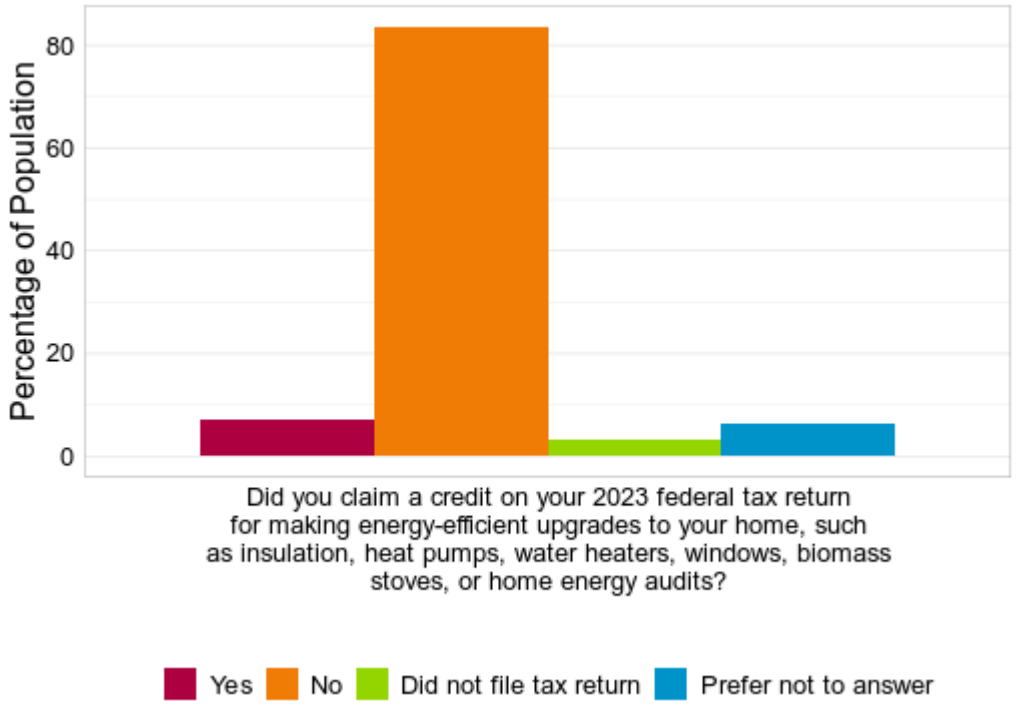
Figure 2-31. Percentage of Population Who Received Financial Assistance Services



Source: Guidehouse analysis

Figure 2-32 shows the percentage of the population who claimed a credit on their 2023 federal tax return for making energy efficient home upgrades. A large majority of respondents reported not claiming a credit.

Figure 2-32. Percentage of Population Who Claimed an Energy Efficient Credit on Their 2023 Tax Return



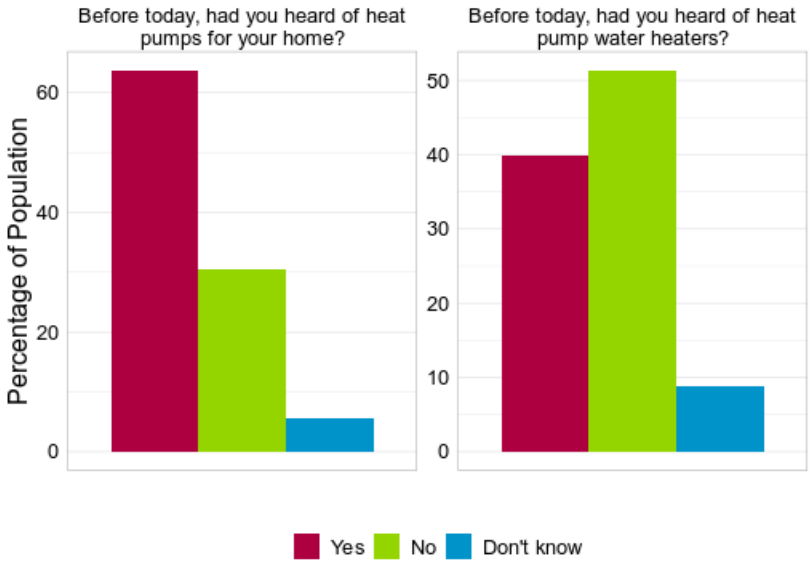
Source: Guidehouse analysis

2.4 Heat Pump Adoption

This section provides the results of the heat pump and heat pump water heater adoption analysis. Guidehouse included questions in the Phase 8 customer survey on the willingness to install a heat pump and heat pump water heater (contained in Appendix A.1).

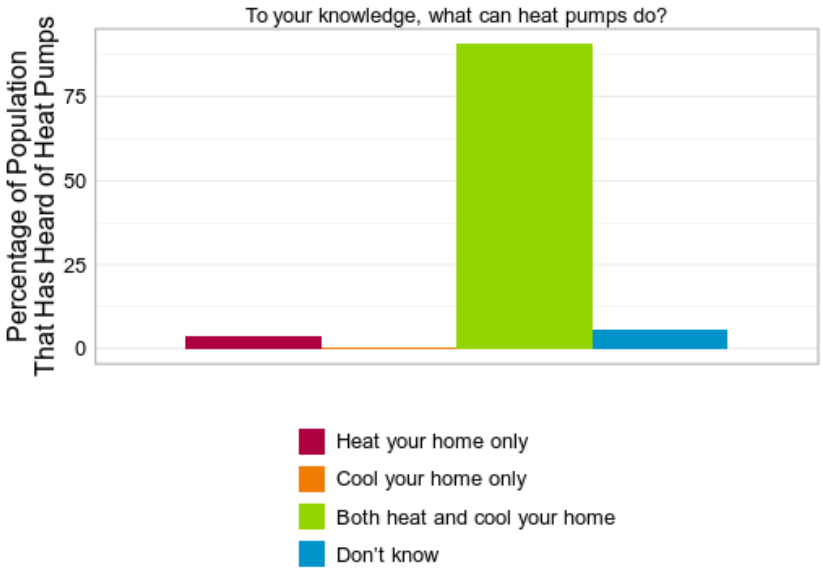
Figure 2-33 shows awareness of heat pumps and heat pump water heaters. Most of the population have heard of heat pumps, but less than half the population have heard of heat pump water heaters. Figure 2-34 shows that for those who have heard of heat pumps, the vast majority are aware that heat pumps both heat and cool a home.

Figure 2-33. Population Awareness of Heat Pumps and Heat Pump Water Heaters



Source: Guidehouse analysis

Figure 2-34. Population Knowledge of Heat Pump Heating and Cooling Capabilities

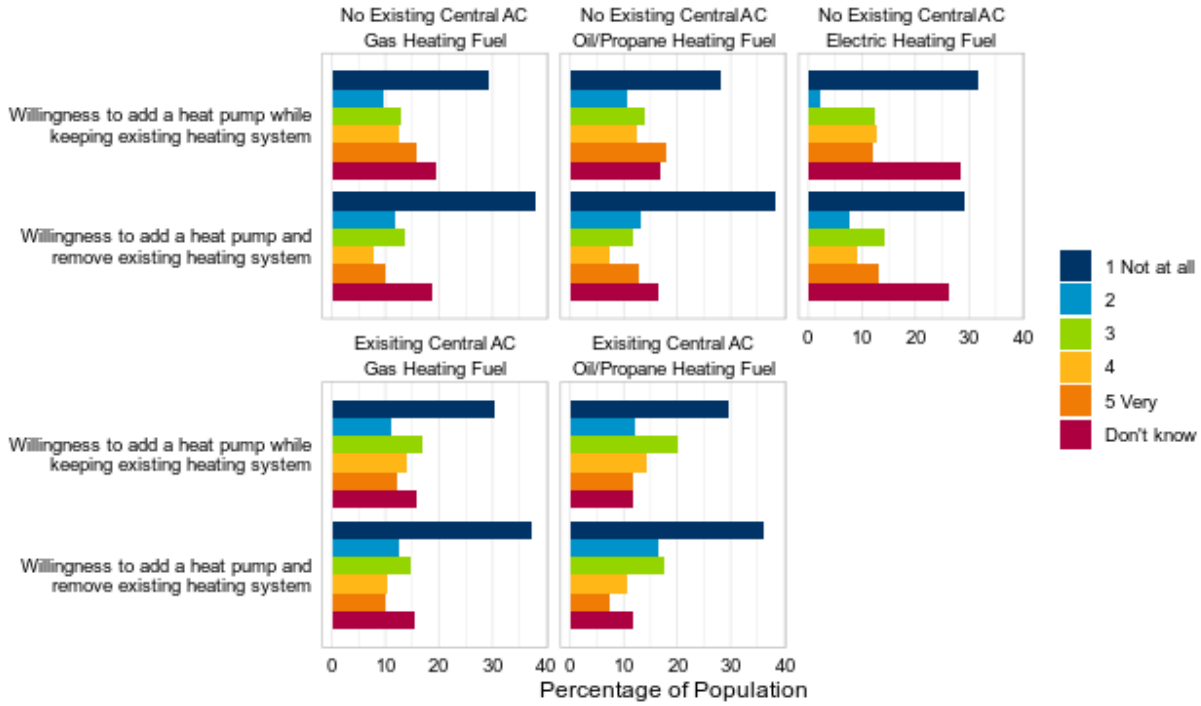


Source: Guidehouse analysis

2.4.1 Willingness to Install a Heat Pump

Figure 2-35 shows respondents' willingness to adopt heat pumps by existing heating system fuel and whether they had an existing central air conditioning system. Overall, the majority of respondents indicate they are not at all willing to add or switch to heat pumps, though 20%-30% were interested. For those with fuel-fired heating systems, there was more willingness to add a heat pump while keeping the existing system as a backup. Interestingly, the opposite was true of those with electric heat. Willingness was also higher in those without an existing central air conditioning system.

Figure 2-35. Heat Pump Willingness by Current Heating Fuel and Cooling System*[8]



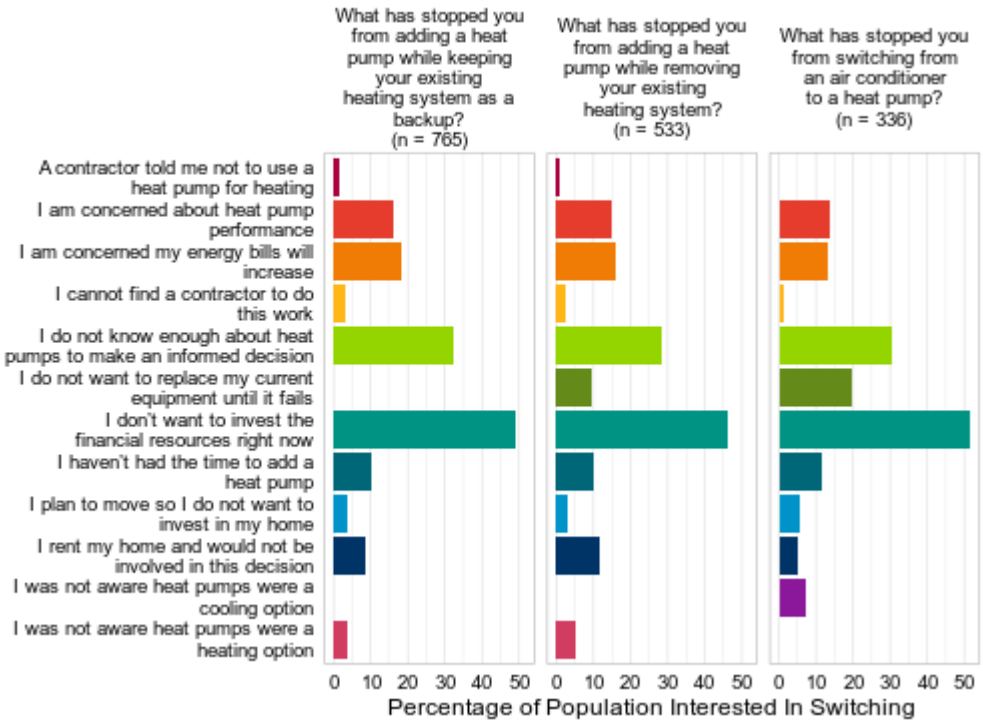
*Interested customers are those who responded with a 4-5; customers who responded with a 1-3 were considered not interested, and those who answered "Don't know" were not given the follow-up questions.

Source: Guidehouse analysis

[8] Data is not shown for Electric Heating Fuel/Existing Central Air Conditioning due to small sample size, likely due to this being an uncommon pairing in the population.

Figure 2-36 shows the rationale given for not yet switching to a heat pump, for those that showed interest. Overall, the primary barriers are installation costs and lack of knowledge about heat pumps, which appear consistently across all scenarios. Secondary concerns include energy bill increases and performance of heat pumps.

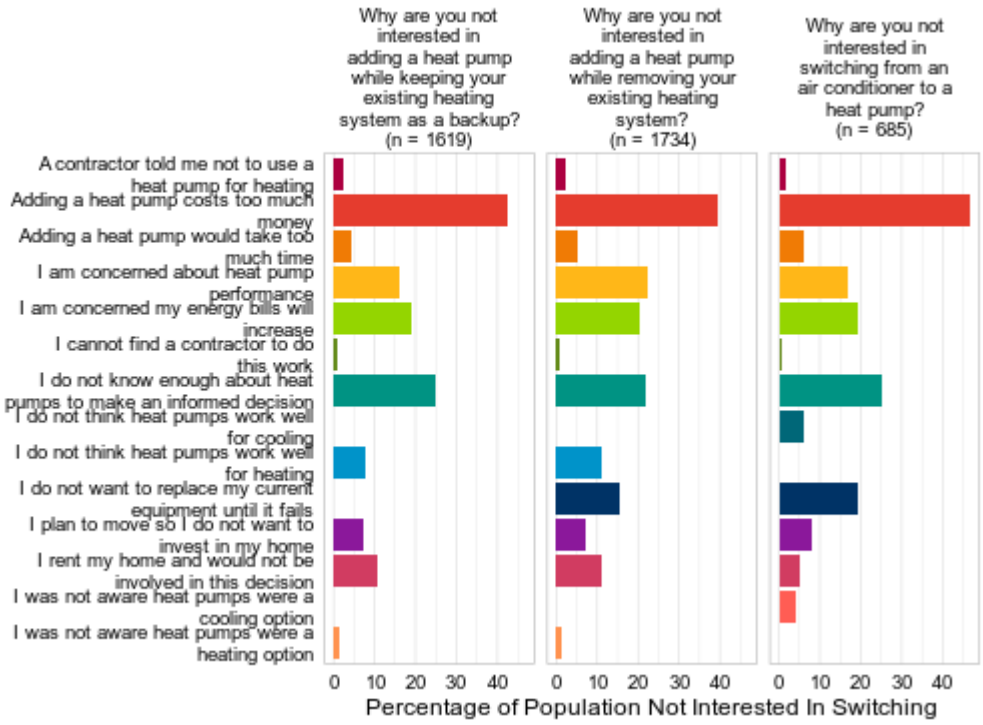
Figure 2-36. Rationale for Not Yet Switching to a Heat Pump System for Interested Customers



Source: Guidehouse analysis

Figure 2-37 shows the rationale given for not switching to a heat pump, for those that are not interested. Similarly to those who were interested, the primary concerns were upfront cost and lack of knowledge of heat pumps, though concerns about energy bills increasing and heat pump performance were similarly prevalent for this group.

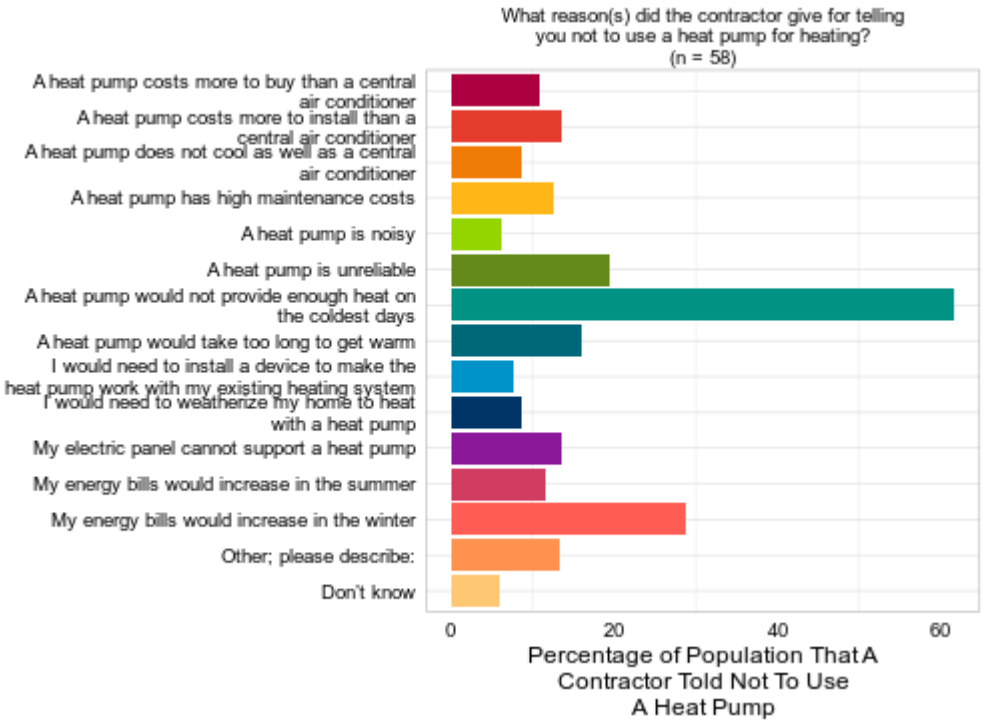
Figure 2-37. Rationale for Not Switching to a Heat Pump System for Non-Interested Customers



Source: Guidehouse analysis

Some respondents indicated that their contractor advised against installing a heat pump. Figure 2-38 shows that most contractors who discourage heat pump installation cite concerns that the system would not provide sufficient heat on the coldest days, and many also indicated that energy bills would increase in the winter.

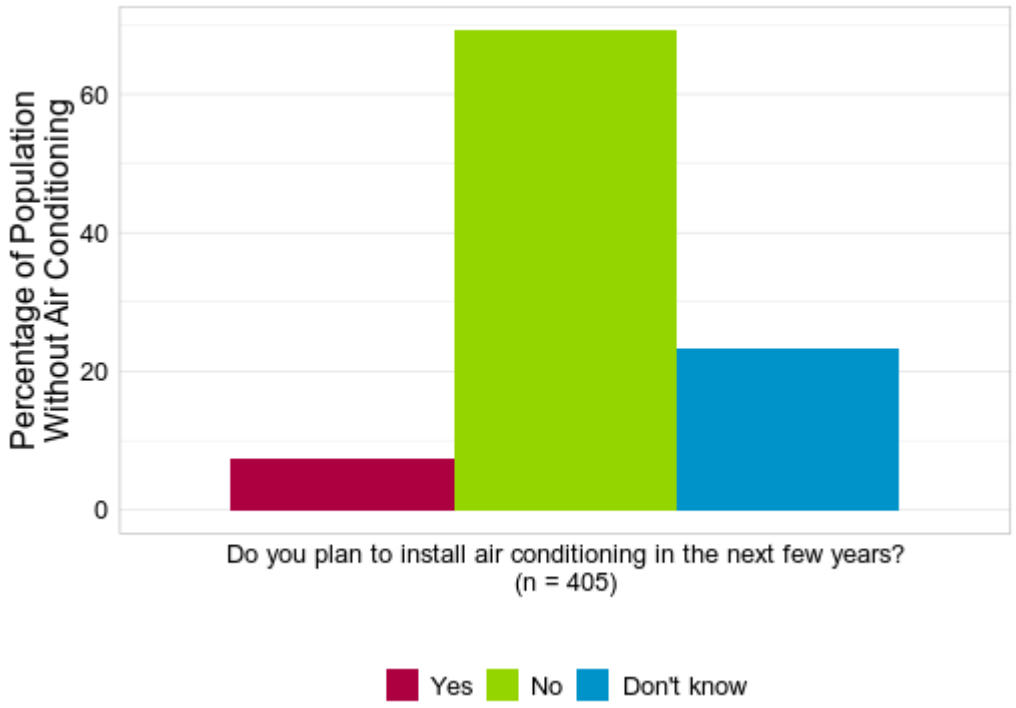
Figure 2-38. Contractor Advice Given Against Using a Heat Pump for Heating



Source: Guidehouse analysis

Figure 2-39 shows that, of the respondents who currently do not have air conditioning (12% of the statewide population), less than 10% plan to install it in the next few years.

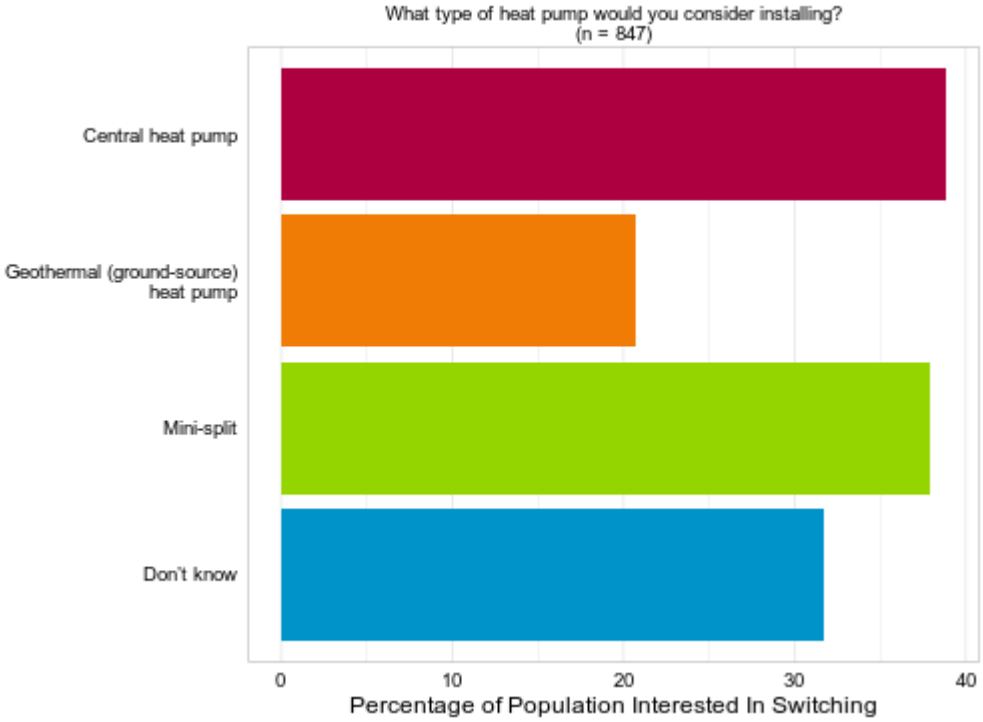
Figure 2-39. Percentage of Population Who Plan to Install Air Conditioning in the Next Few Years



Source: Guidehouse analysis

Figure 2-40 shows the heat pump types of interest for those who indicated willingness to install a heat pump. People showed similar interest in central heat pumps and mini-split heat pumps, while ground-source heat-pumps were less appealing.

Figure 2-40. Types of Heat Pumps Interested Customers Would Consider Installing

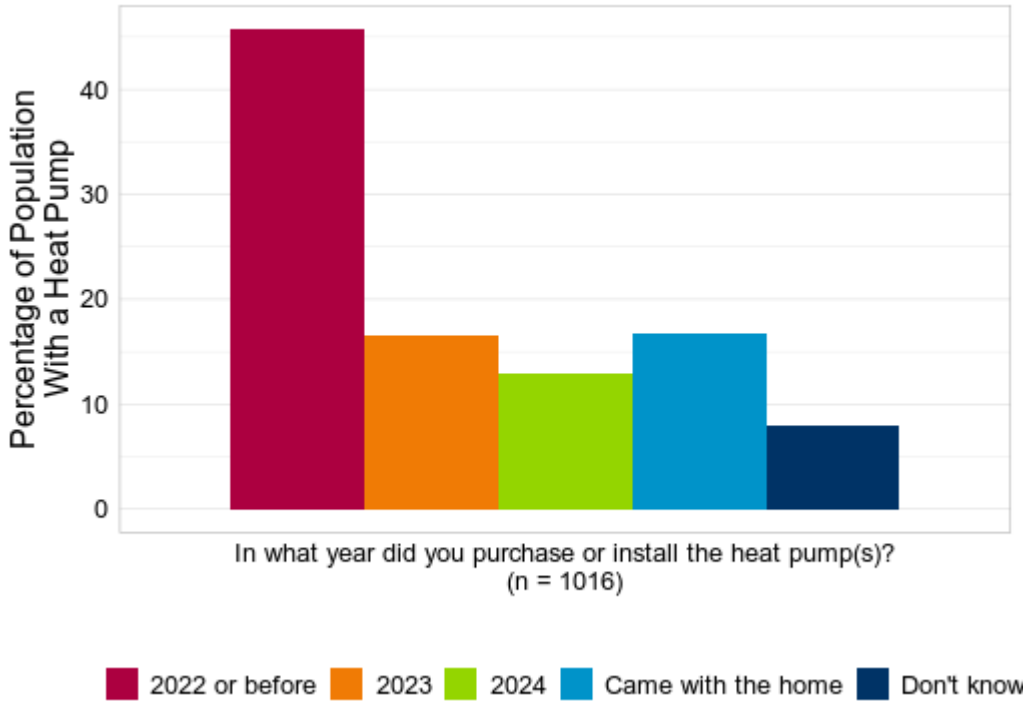


Source: Guidehouse analysis

2.4.2 Heat Pump Installation and Purchase Decisions

Figure 2-41 shows the distribution of when people purchased or installed heat pumps. Almost half of heat pumps were installed in 2022 or earlier, though over a quarter were installed in the past 2 years.

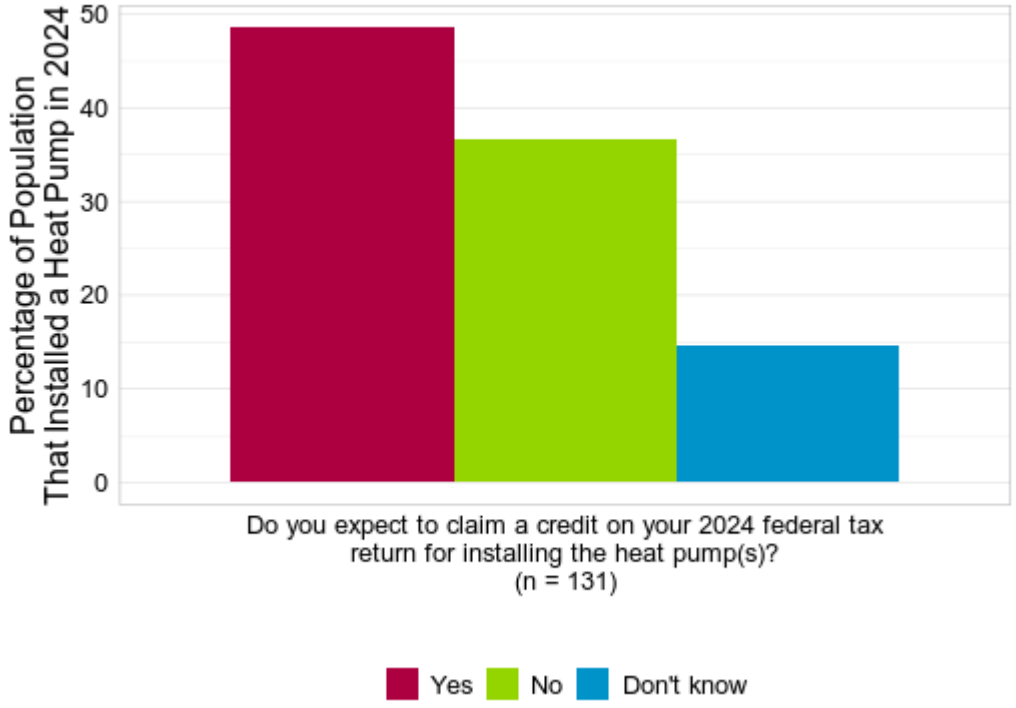
Figure 2-41. Heat Pump Year of Installation



Source: Guidehouse analysis

Figure 2-42 shows respondents' expectations regarding claiming a federal tax credit on their 2024 tax return for installing heat pumps in that year. Only about half of respondents expect to claim the credit, indicating that a significant portion either does not intend to claim it or lacks clarity on eligibility.

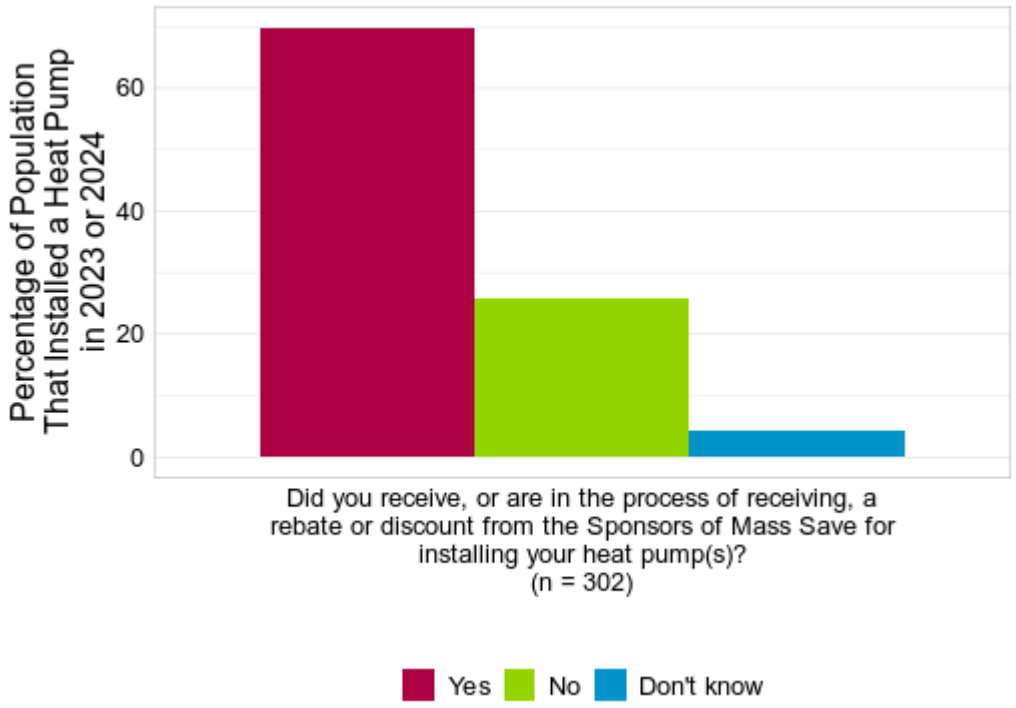
Figure 2-42. Percentage of Population Who Will Receive a Federal Tax Credit on Their Heat Pump Purchase



Source: Guidehouse analysis

Figure 2-43 shows the proportion of those who installed a heat pump in the past 2 years who received a rebate or discount from the Sponsors of Mass Save. About two-thirds reported receiving or expecting the rebate, indicating that Mass Save rebates are widely accessed.

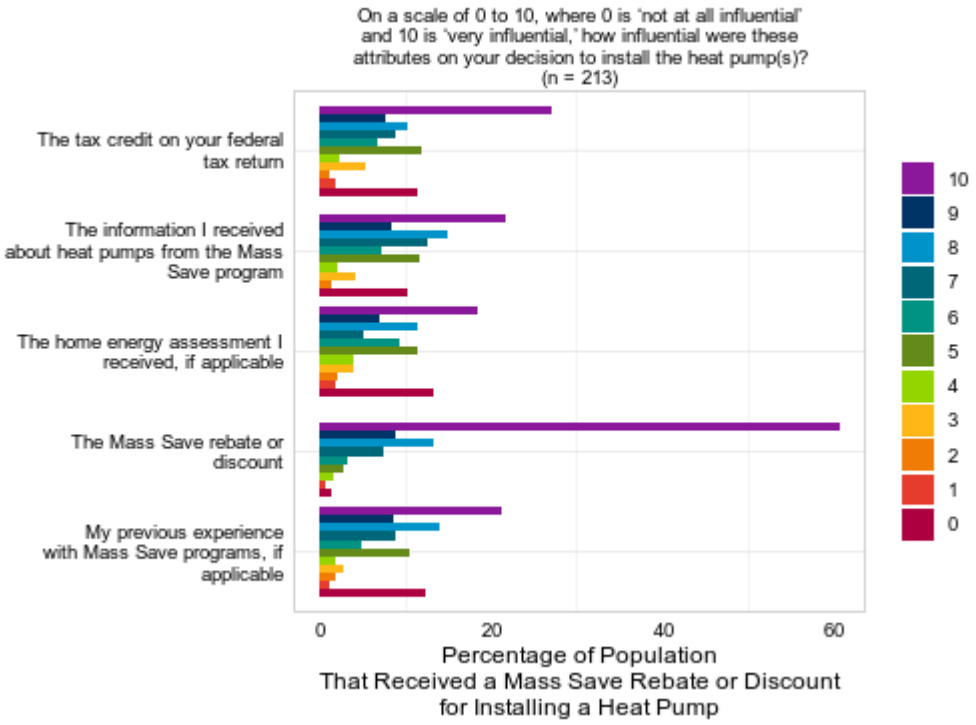
Figure 2-43. Percentage of Population Who Received a Rebate from Mass Save



Source: Guidehouse analysis

Figure 2-44 illustrates how influential various factors were in participants' decisions to install heat pumps, rated on a scale from 0 (not at all influential) to 10 (very influential), for those who received a Mass Save rebate or discount. The rebate or discount stands out as the most influential factor, with federal tax credits being the second most influential. Information from the Mass Save program and home energy assessments also show strong influence.

Figure 2-44. Influential Attributes on the Decision to Install a Heat Pump

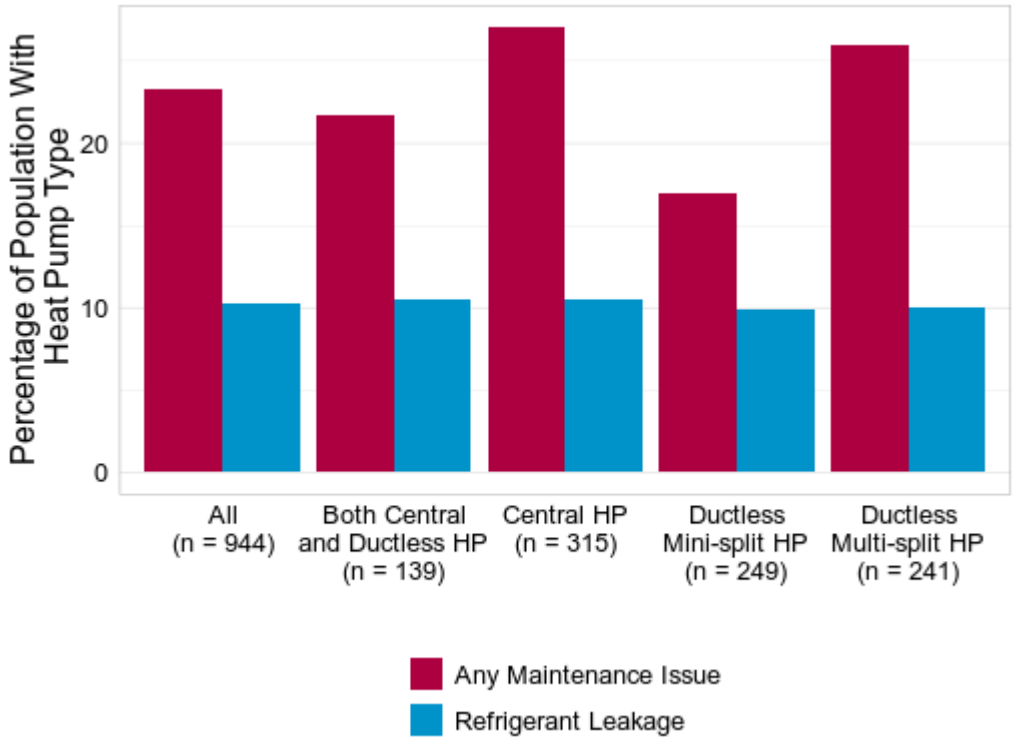


Source: Guidehouse analysis

2.4.3 Heat Pump Maintenance Issues

Figure 2-45 shows the rate of maintenance issues reported by heat pump owners split by heat pump type, with ductless heat pumps separated into mini-split (one indoor unit) and multi-split (multiple indoor units). There was a relatively high rate of maintenance issues in general (23%) and refrigerant leakage in particular (10%) across all heat pump types. Central heat pumps and ductless multi-split heat pumps showed higher rates of overall maintenance issues, but the rate of refrigerant leakage was similar across heat pump types.

Figure 2-45. Maintenance Issues Experienced by Heat Pump Type

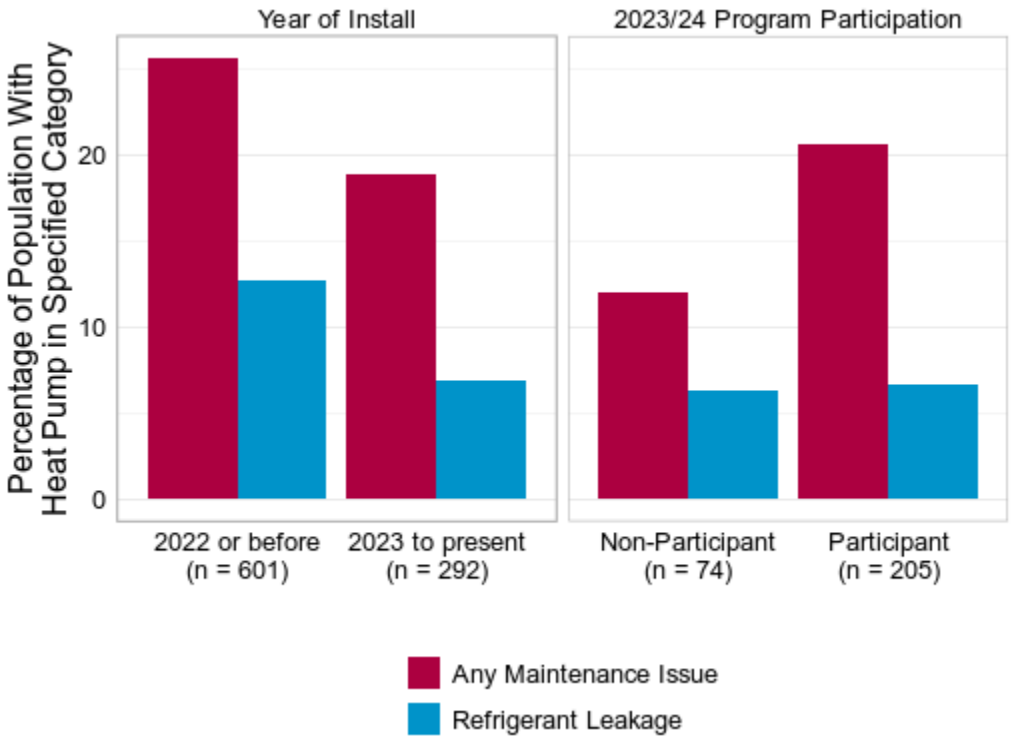


Source: Guidehouse analysis

Figure 2-46 shows the prevalence of heat pump maintenance issues by installation year and whether the heat pump was installed as part of the Mass Save program. Both general maintenance issues and refrigerant leakage were more common among older units, which may be due either to improved quality in more recent installations or just to the fact that older units have operated for a longer period. As a result, it's not clear from this data that the rate of maintenance issues is higher.

Among customers who installed their heat pumps in 2023 or 2024, the proportion who reported refrigerant leakage was similar between those who installed it through the Mass Save program and those who did not, and overall maintenance issues were reported more frequently among program participants. This suggests an opportunity for program improvements to reduce maintenance needs, such as incorporating quality installation requirements or enhanced contractor training.

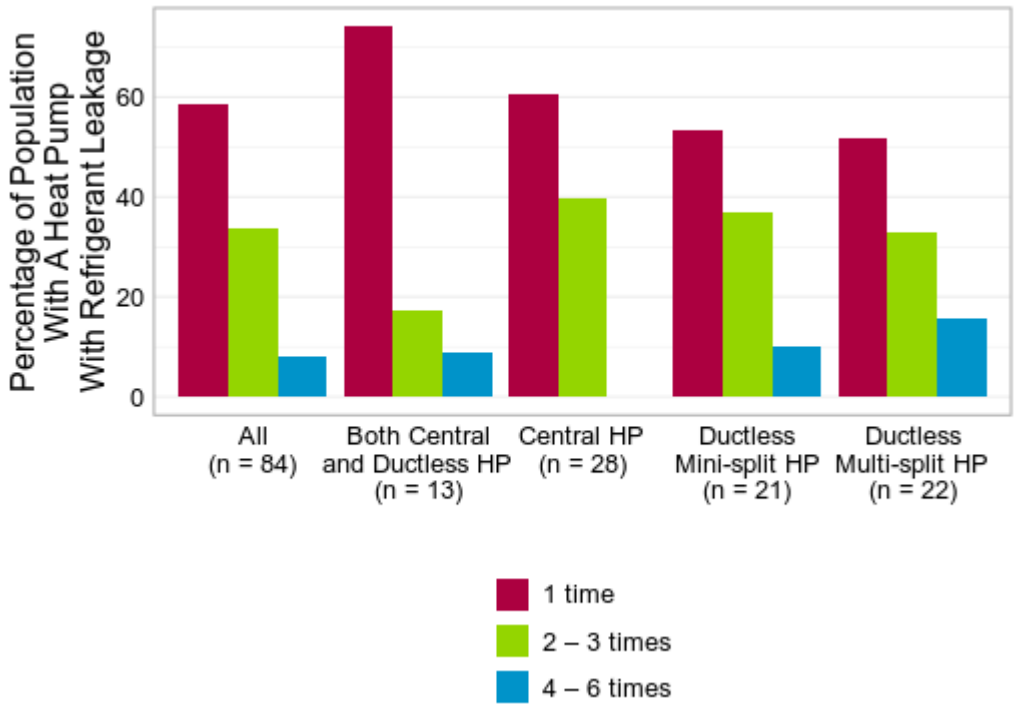
Figure 2-46. Maintenance Issues Experienced by Install Year and Participation



Source: Guidehouse analysis

Figure 2-47 shows the distribution of the total number of refrigerant leaks for those respondents who reported one. Across all heat pump types, over 40% of those with refrigerant leaks indicated having experienced multiple leaks. The rate of multiple leaks was higher for ductless heat pumps (both mini-split and multi-split) than for central heat pumps.

Figure 2-47. Frequency of Refrigerant Leakage by Heat Pump Type for Those Who Reported a Leak

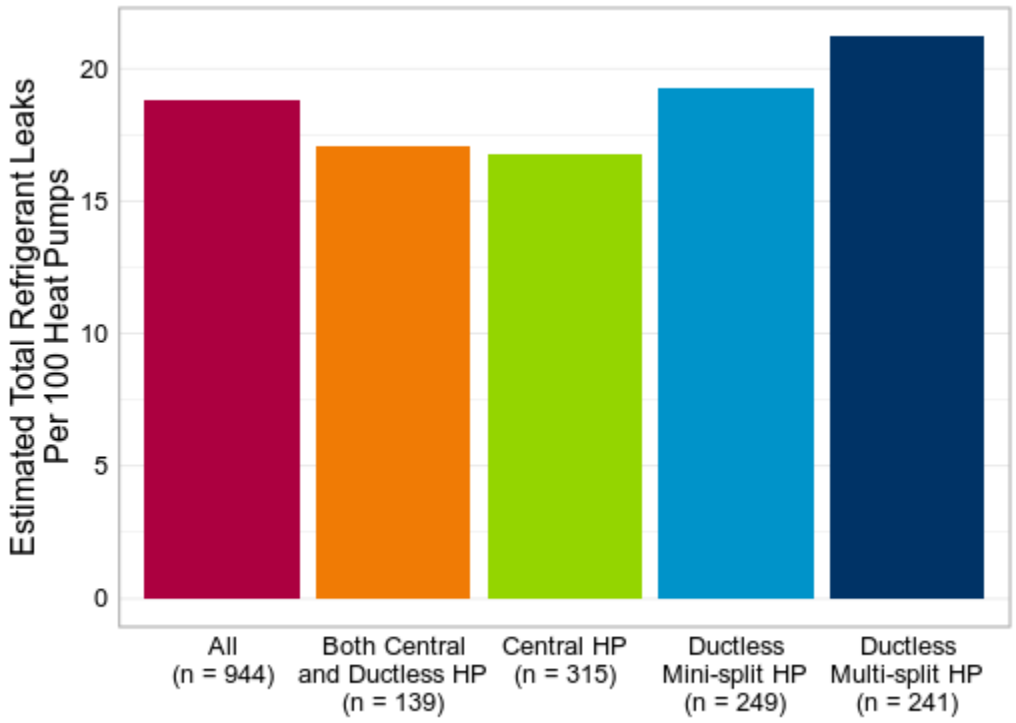


Source: Guidehouse analysis

Key Finding: Frequent maintenance issues, especially refrigerant leaks, among heat pump owners pose a significant barrier to market growth and customer satisfaction.

Combining the rate of refrigerant leakage with the number of leaks (and assuming the middle of the ranges of the latter), Figure 2-48. shows an estimate of the total number of refrigerant leaks per 100 heat pumps, by heat pump type. This estimate works out to 19 leaks per 100 heat pumps across all types. There was relatively little variation across heat pump types, with ductless multi-split heat pumps having the highest total (21) and central heat pumps having the lowest (17).

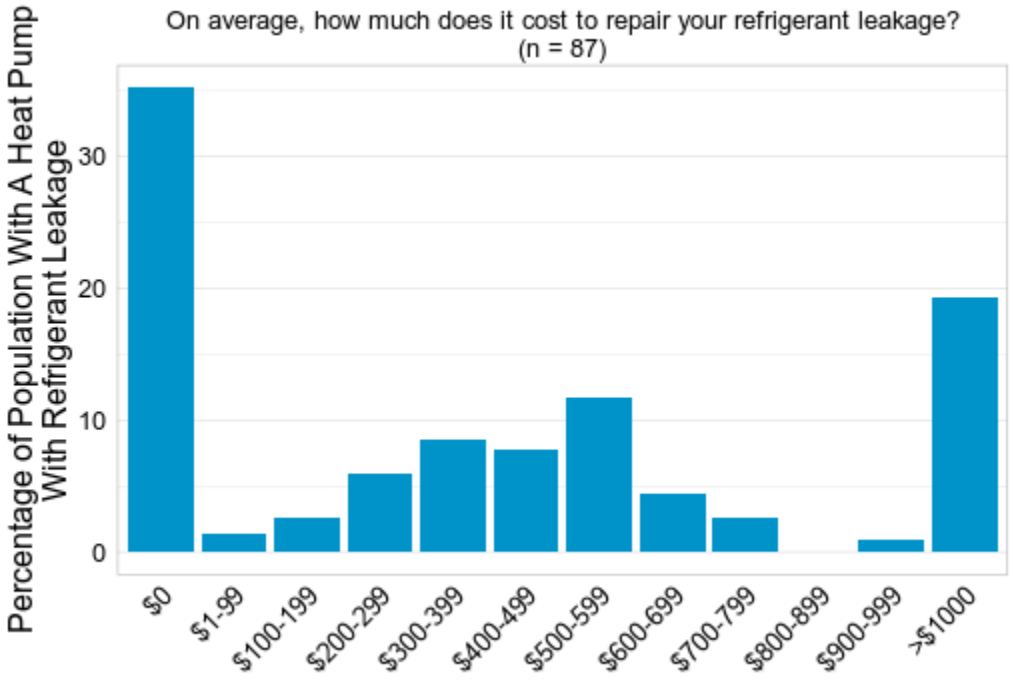
Figure 2-48. Total Refrigerant Leaks by Heat Pump Type



Source: Guidehouse analysis

Figure 2-49 shows the average cost (per leak) to repair a refrigerant charge leak, for those who reported one. A wide range of costs were reported, with 35% responding $0 and almost 20% responding >$1,000. The zero-cost repairs may be due to the repair falling in the warrantee period, which could indicate that these leaks were detected shortly after installation.

Figure 2-49. Average Cost to Repair Refrigerant Leakage Per Leak

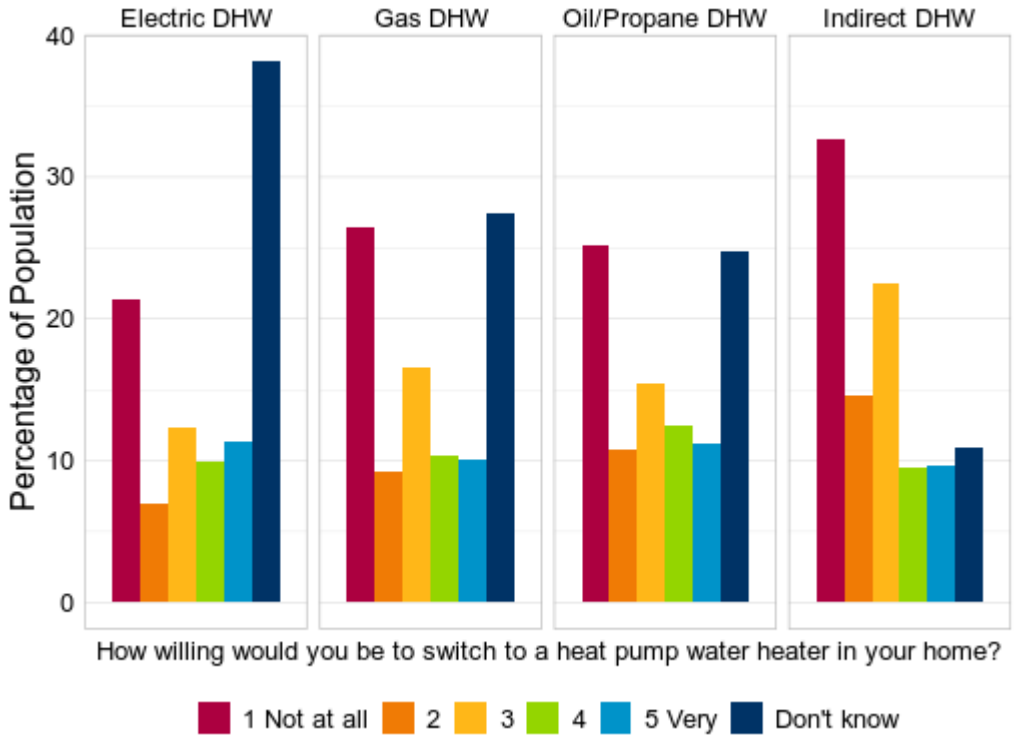


Source: Guidehouse analysis

2.5 Heat Pump Water Heater Adoption

Figure 2-50 shows respondents' willingness to adopt heat pump water heaters by existing water heater type. About 20% of the population indicated they were interested in switching to a heat pump water heater (4 or 5) across types, with slightly higher rates for those with existing electric, oil, or propane domestic hot water (DHW) and slightly lower rates for those with indirect DHW.

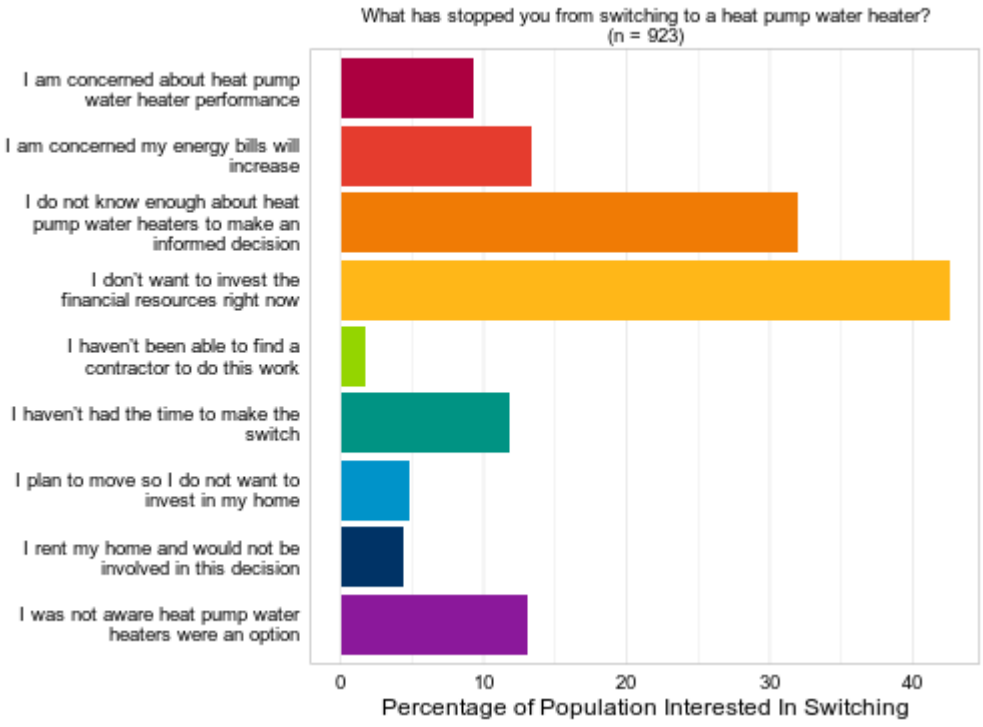
Figure 2-50. Heat Pump Water Heater Willingness to Adopt by Existing Water Heater Type



Source: Guidehouse analysis

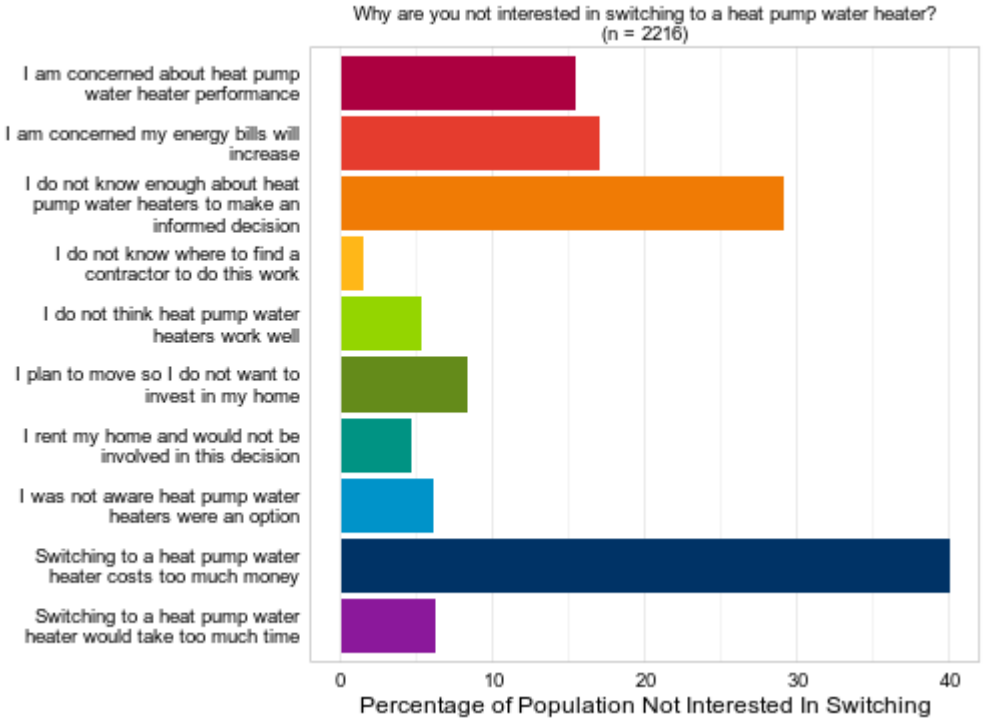
Figure 2-51 and Figure 2-52 show the rationale for not yet switching to a heat pump water heater (for those that are interested) or for not switching (for those not interested). In both cases, the primary reasons given were the cost of installation and lack of knowledge about heat pump water heaters.

Figure 2-51. Rationale for Not Yet Switching to a Heat Pump Water Heater for Interested Customers



Source: Guidehouse analysis

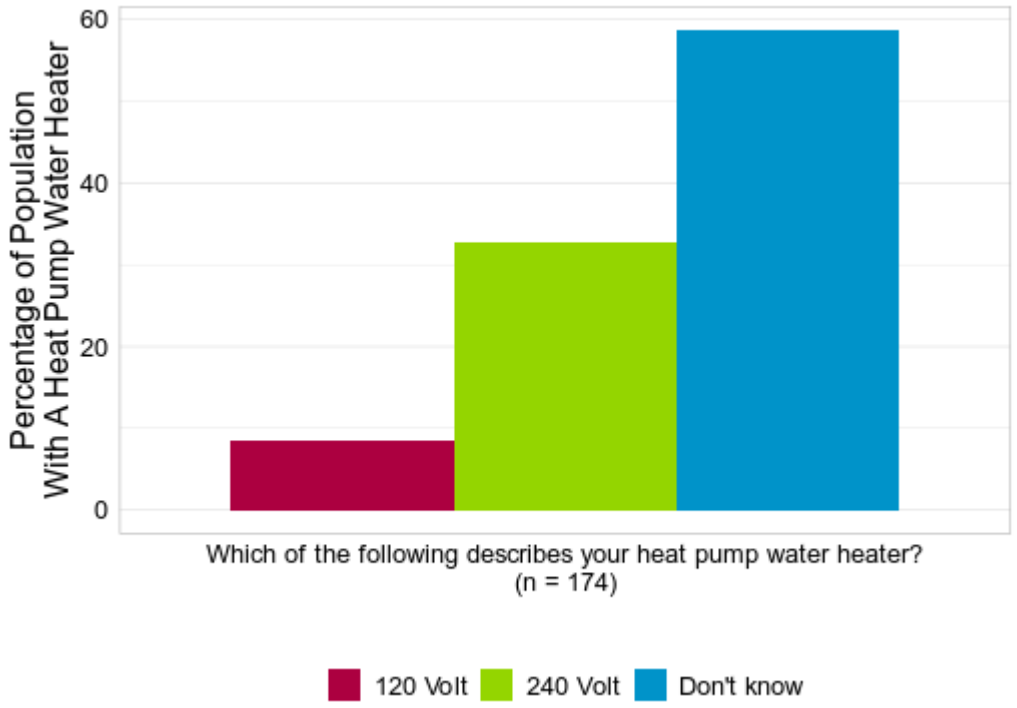
Figure 2-52. Rationale for Not Switching to a Heat Pump Water Heater for Customers Who Are Not Interested in Switching



Source: Guidehouse analysis

Figure 2-53 shows the proportion of heat pump water heater types present in the population. Most respondents do not know the voltage of their heat pump water heater, while among those who do, 240-volt units are far more common than 120-volt units.

Figure 2-53. Heat Pump Water Heater Type



Source: Guidehouse analysis

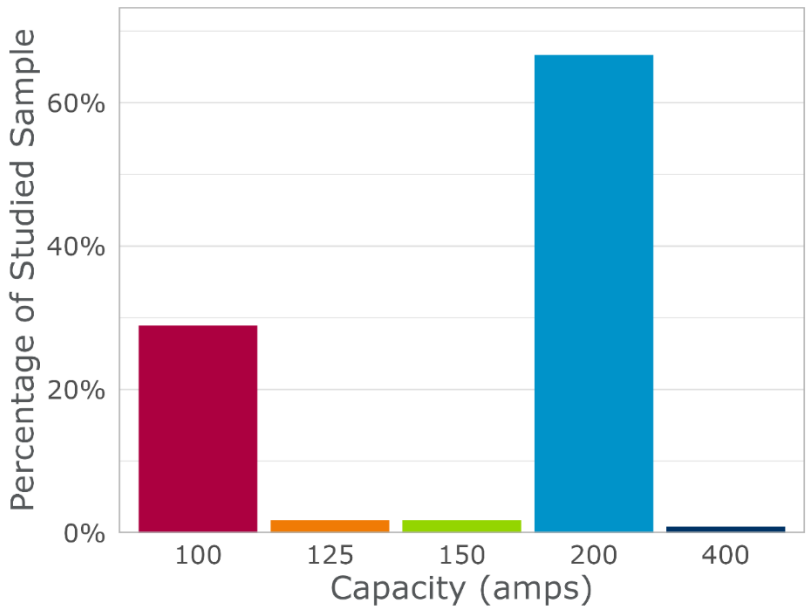
2.6 Electrification Readiness

To help understand the potential for replacing fossil fuel consumption in homes with electricity, the team performed an analysis of the available capacity of existing electrical panels. This analysis included determining what additional electrical capacity the existing service and its components can safely support under current codes, and comparing available capacity to what would be needed for full electrification. The analysis was based on photographs of participants' electrical panels collected via the survey, and relies on service load calculations from the National Electrical Code (NEC). The full methodology is detailed in Section 4.2A.2.2.

Electrification is not a simple yes-or-no decision, as most homes already have some electrical appliances—even homes with natural gas service. For example, many homes with gas service still have electric clothes dryers or cooking ranges and some have electric resistance water heaters. Increasingly, homes are converting from electric resistance and fossil fuel water heating to heat pump water heaters and many are adding heat pumps for cooling, supplemental heating, or whole-home heating. As a result, all homes have some degree of appliance electrification and varying amounts of remaining electrical capacity.

Out of the 445 panel photographs received, 171 were from single-family homes and were of sufficient quality to determine overall electrical capacity. As Figure 2-54 shows, about 30% of these homes had 100A panels and more than 65% had 200A panels. Of these, 109 panels (100A and 200A) contained enough detail for further analysis.

Figure 2-54. Panel Capacities in Studied Sample

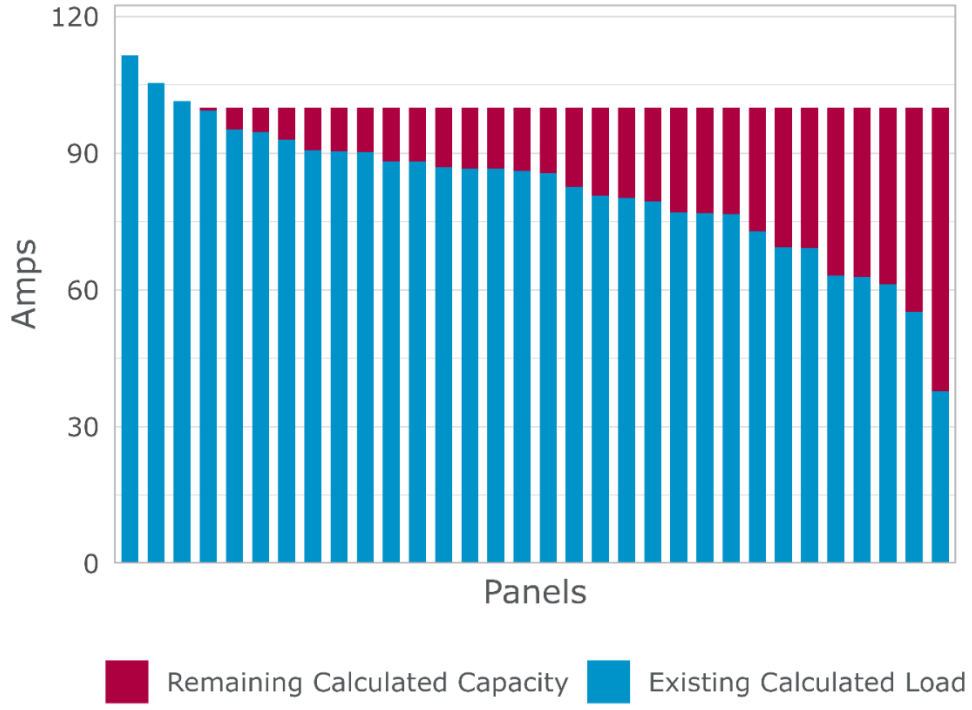


Source: Guidehouse analysis

2.6.1 100A Panel Electrification Readiness

Figure 2-55 shows the existing capacity of the 100A panels. Most had remaining capacity even with some level of electrical appliances and HVAC. However, about 10% are already over code capacity and another 10% are so near capacity that no additional major loads can be added.

Figure 2-55. 100A Panel Existing Capacities



Source: Guidehouse analysis

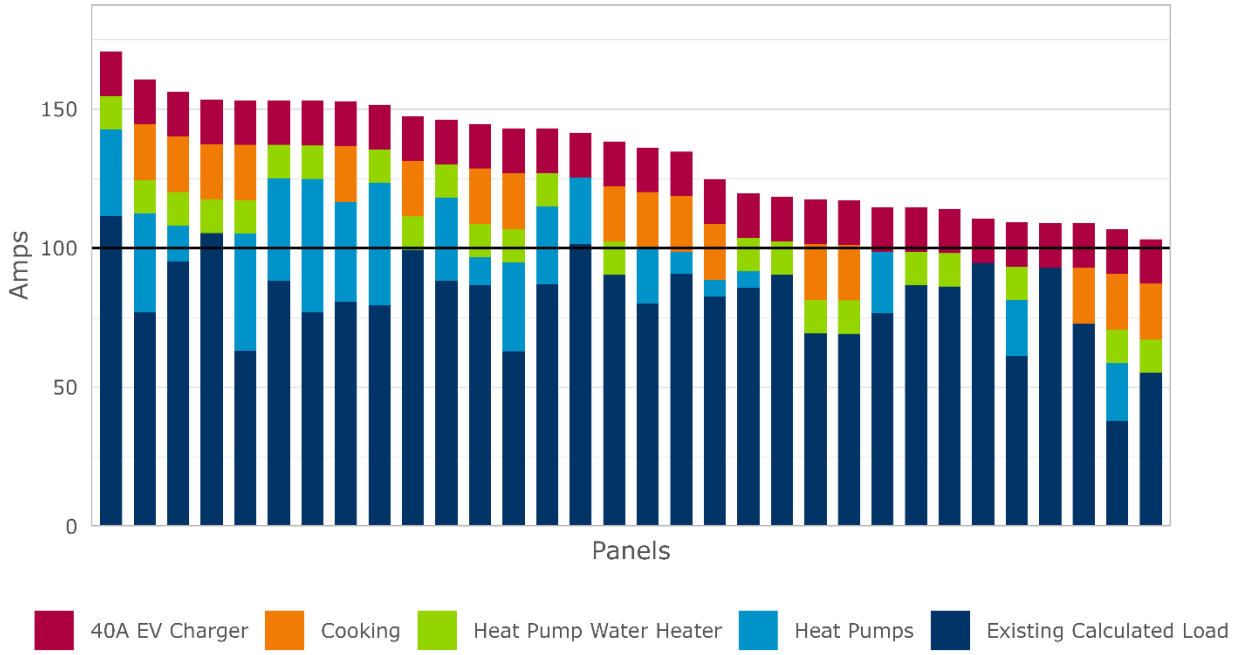
The team began by evaluating electrical panels to determine their capacity for supporting additional loads from home electrification. First, they added the electrical demand required for heating with heat pumps. For homes without an existing central air conditioner, the team included the summer heat pump load, as replacing a central air conditioner would not introduce a new load.

With these changes, about 45% of the evaluated panels would exceed their capacity if full heat pump heating were implemented. Next, the team added the load for a heat pump water heater in homes without electric water heating and included a 12 kW electric range for homes without electric cooking.[9] This cooking load was chosen for illustration, acknowledging that some homes may install larger ranges or dual ovens. At this stage, 80% of homes with 100A panels would be over capacity.

[9] The team used 30A and 50A breakers to represent heat pump water heaters and electric cooking, respectively. The team's methodology to convert from breaker sizes to estimated capacity is detailed further in Appendix 4.2A.2.2.

Finally, the team added the load for a 40A EV charger, which is a conservative estimate given that many Level 2 chargers now exceed this rating. With this level of electrification, all 100A panels evaluated would be over capacity, as Figure 2-56 shows.

Figure 2-56. Capacity of 100A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and EV Chargers

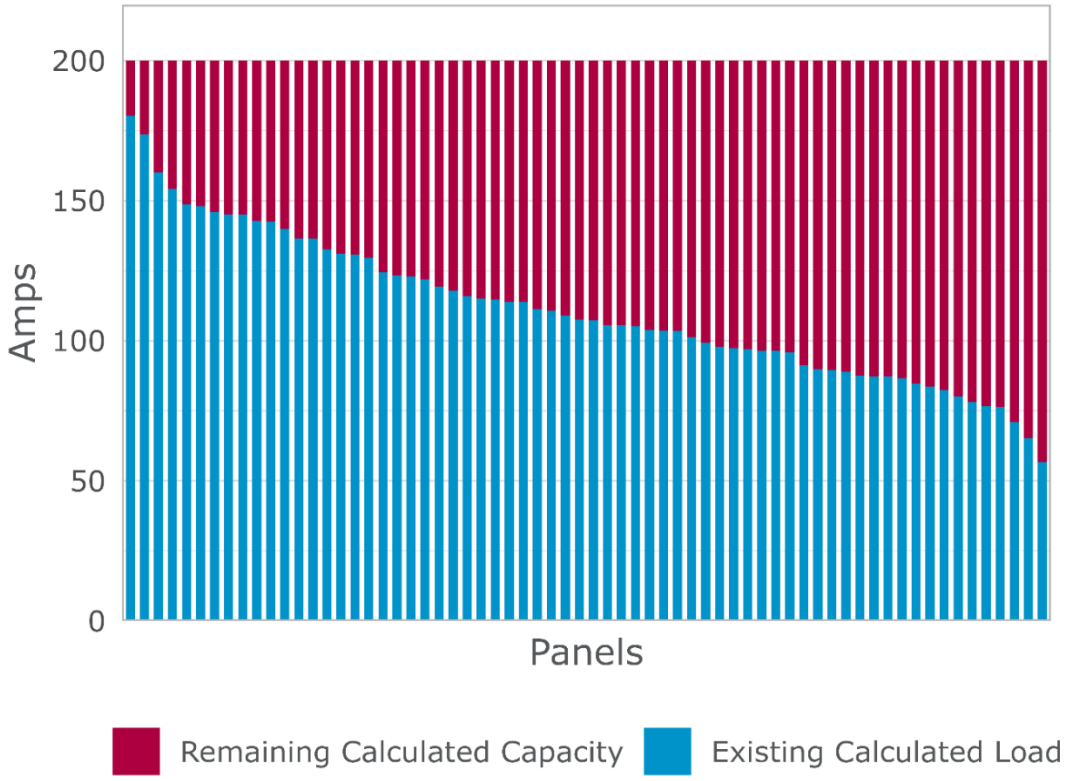


Source: Guidehouse analysis

2.6.2 200A Panel Electrification Readiness

Figure 2-57 displays the calculated load and remaining capacity for homes with 200A electrical panels. All panels shown have remaining capacity, even after accounting for existing electrical appliances and HVAC systems. However, the amount of unused capacity varies and is often less than the full additional 100A that might be expected. This finding is likely because these panels are found in larger homes or homes with higher levels of electrification, which increases the existing load and reduces the remaining available capacity.

Figure 2-57. 200A Panel Existing Capacities

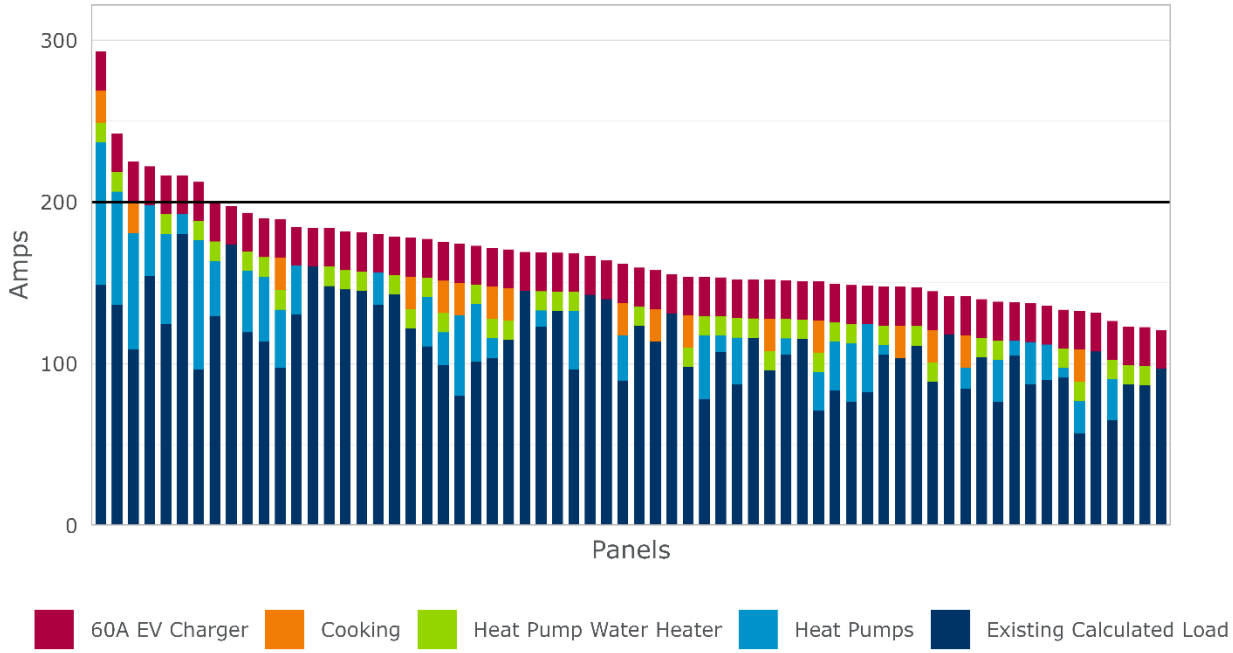


Source: Guidehouse analysis

The team evaluated 200A electrical panels to assess their ability to support increased electrification. First, they added the load for whole-home heat pumps, following the same approach used for 100A panels. Only two of the 200A panels exceeded their capacity with this addition. Next, the team included heat pump water heaters and electric cooking loads. At this stage, all but two panels remained within capacity.

To reflect likely future scenarios, the team then added a 60A EV charger to each panel—larger than the 40A charger used for 100A panels, as homeowners would typically upgrade before installing a high-capacity charger. With this addition, about 10% of homes were slightly over capacity, as the first plot in Figure 2-58 shows.

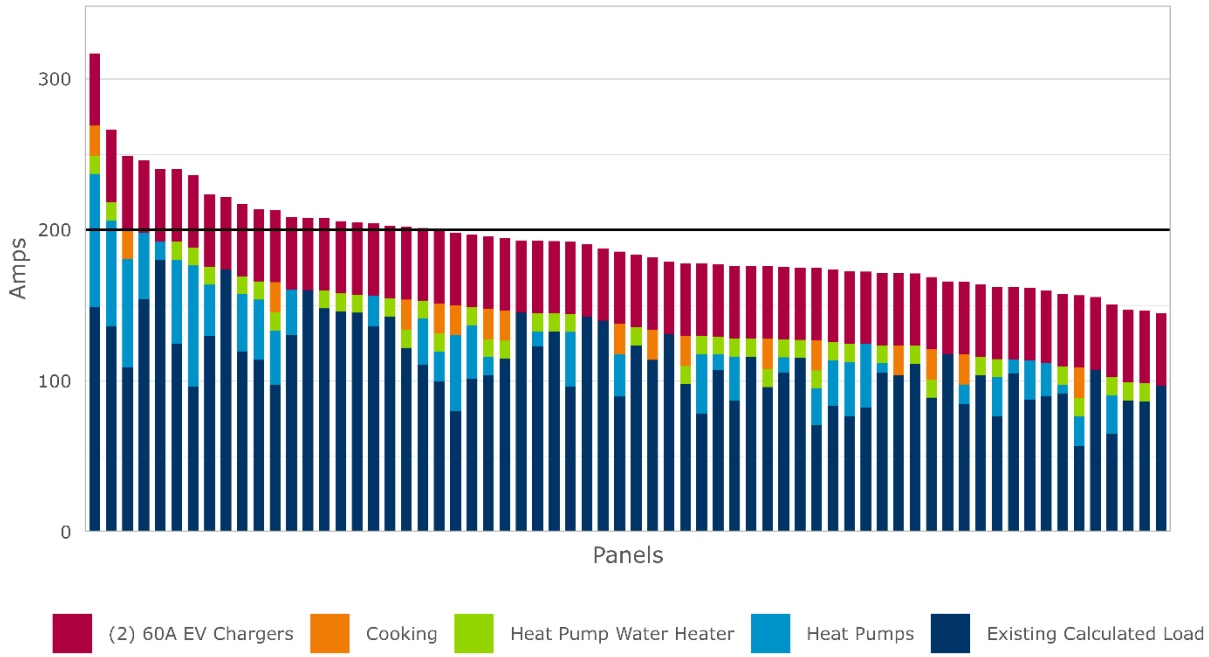
Figure 2-58. Capacity of 200A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and a 60A EV Charger



Source: Guidehouse analysis

Anticipating that many homes may eventually have two EVs, the team added a second 60A EV charger in the analysis (Figure 2-59). With full home heat pumps, a heat pump water heater, electric cooking, and two 60A EV chargers, approximately 25% of homes with 200A panels would be over capacity.

Figure 2-59. Capacity of 200A Panels with Full Home Heat Pumps, Heat Pump Water Heater, Cooking, and Two 60A EV Chargers



Source: Guidehouse analysis

2.6.3 Electrical Panel Load Management

Modern electrical panels offer dynamic load management, allowing users to automatically limit total electrical consumption based on user-defined or automated logic. Traditionally, homes with backup generators require a separate generator panel, which included only essential circuits—such as the refrigerator, well pump, or furnace fan—to be powered during outages.

Today's smart panels eliminate the need for a separate generator panel. Instead, all circuits remain in a central panel, and intelligent breakers use software logic to manage loads within the generator's capacity. These panels can also optimize energy usage for battery backups or take advantage of time-of-use electricity rates.

The 2023 NEC introduced a new provision in Article 220 (Service Calculations) addressing EMSs and load control. Section 220.70 states: "If an EMS is used to limit the current to a feeder or service in accordance with 750.30, a single value equal to the maximum ampere setpoint of the EMS shall be permitted to be used in load calculations for the feeder or service. The setpoint value of the EMS shall be considered a continuous load for the purposes of load calculations."

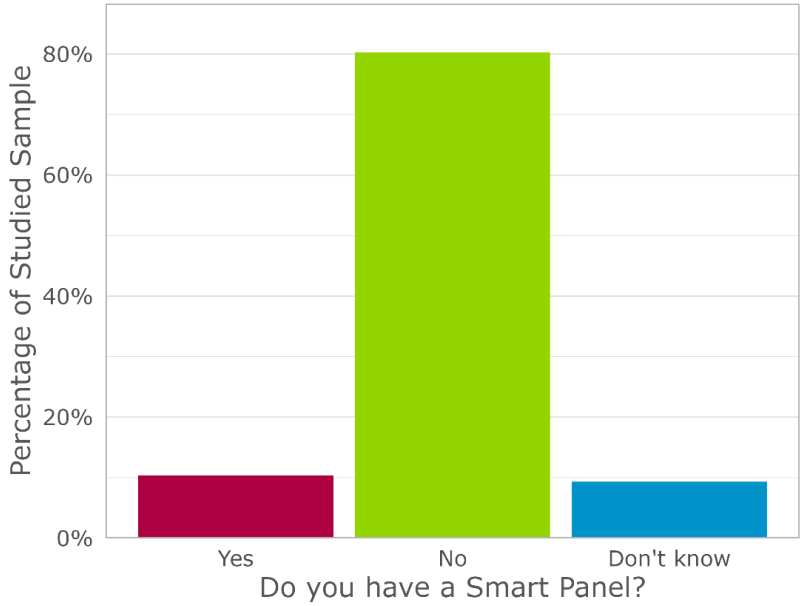
Smart panels can either supplement existing panels or replace them entirely. For example:

- Lumin Smart Panel acts as an add-on to an existing panel.
- SPAN Panel[10] serves as a full replacement.

In electrification scenarios where the total load slightly exceeds panel capacity, a smart panel can replace the existing one without needing a larger upgrade. For instance, installing an EV charger in a home with a fully loaded 100A panel could be feasible by replacing it with a smart panel that schedules charging during off-peak hours.

The Phase 8 survey asked homeowners whether they had a smart panel installed. The results, seen in Figure 2-60, show that smart panel adoption is very low among surveyed households with only about 10% confirmed having one.

Figure 2-60. Customer-Reported Smart Panels in Studied Sample



Source: Guidehouse analysis

[10] SPAN Panel website, https://www.span.io/panel.

3. Detailed Findings

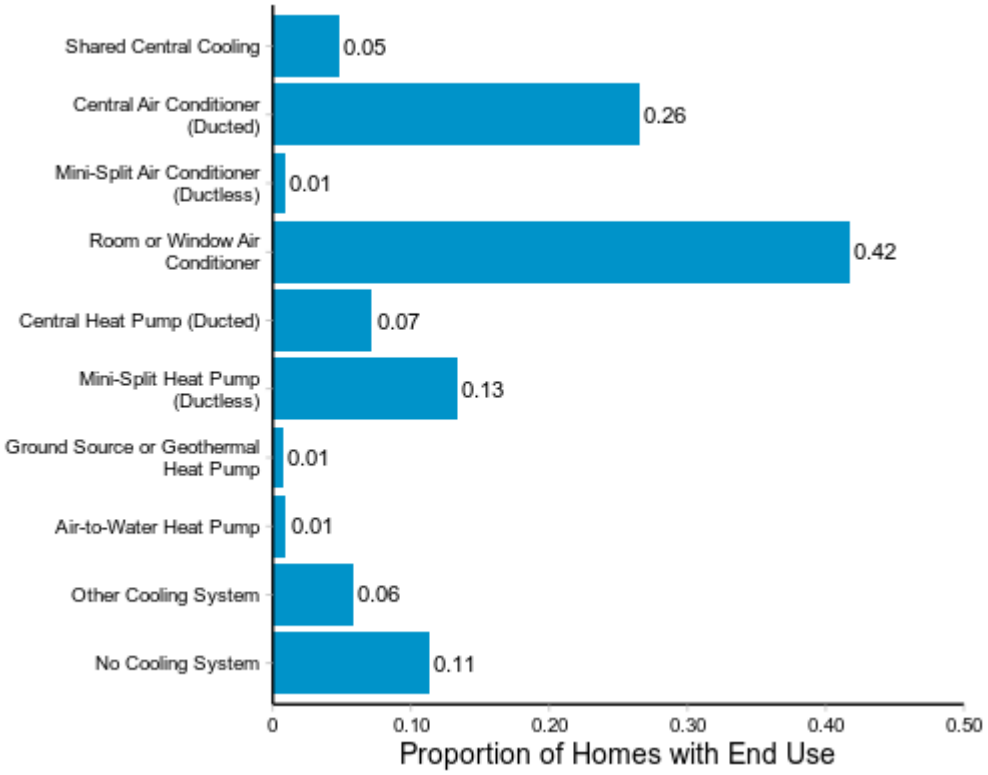
This section expands on the key findings provided in Section 2 to include saturation and characterization at the end use level. It also presents miscellaneous findings from the customer survey for each end use category. Characterization data, such as unit capacities and efficiencies, were collected via nameplate photos and manufacturer and model number lookups. Appendix B contains comprehensive plots and datasets of end use saturation and characterization summaries for additional demographic and building characteristic splits.

3.1 HVAC End Uses

The next several figures relate to the saturation and change in saturation for new equipment and characterization of existing and new equipment for HVAC end uses. The figures start with cooling season end uses, followed by heating season end uses, and finally for miscellaneous HVAC end uses. Figure 3-1 shows the current saturation of cooling end uses.

The data highlights that room/window air conditioners dominate, followed by ducted central systems, while heat pumps and alternative systems have smaller shares. A significant minority lacks any cooling system.

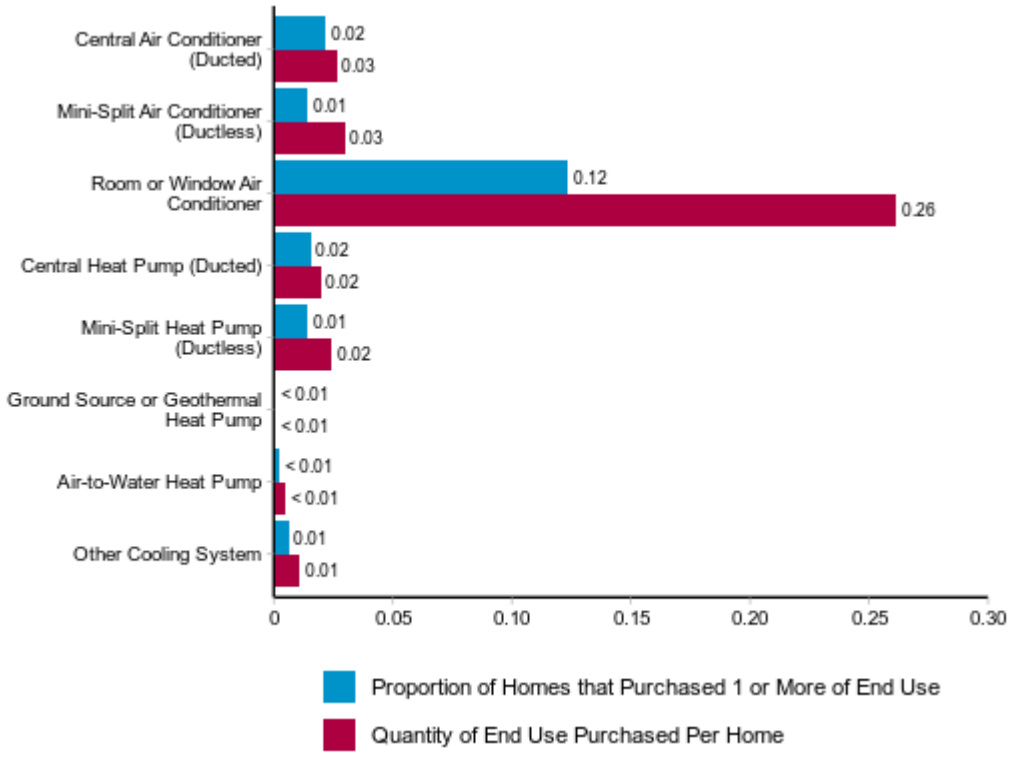
Figure 3-1. HVAC Cooling Equipment Saturation



Source: Guidehouse analysis

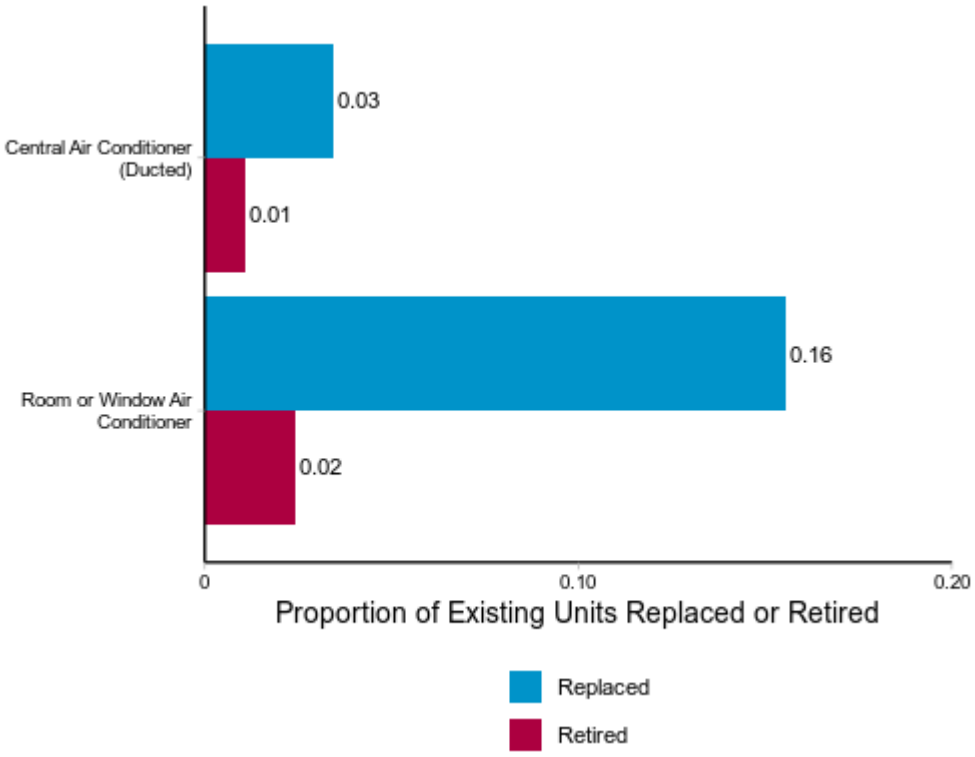
Figure 3-2 and Figure 3-3 provide supporting documentation for the current saturation by showing the number of residents that purchased new equipment (number of homes that purchased the HVAC end use in the past year) and the proportion of removed equipment in Massachusetts in the past year (number of units replaced or retired over all households).

Figure 3-2. Proportion of Homes that Purchased Cooling Season HVAC End Uses in the Past Year



Source: Guidehouse analysis

Figure 3-3. Proportion of Cooling Season HVAC End Uses Replaced or Retired in the Past Year

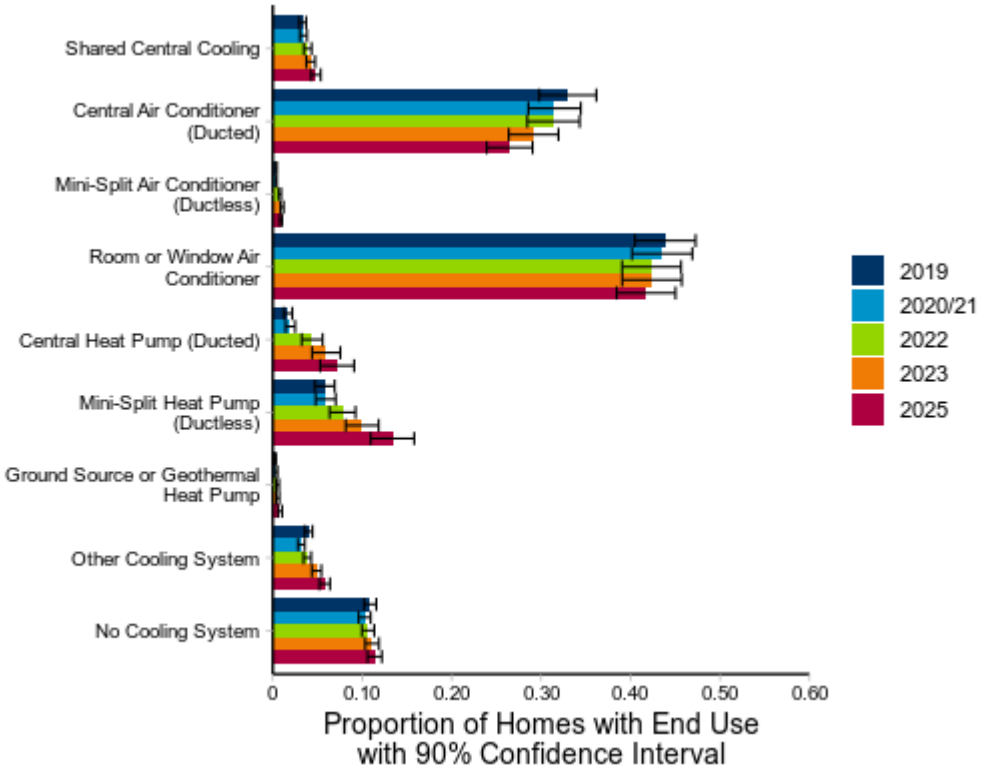


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-4. shows the trends in saturation between 2018 and 2025 for cooling end uses. The data highlights a dominant reliance on room/window air conditioners, steady decrease in use of central air systems, and emerging growth in heat pump adoption between 2019 and 2025.

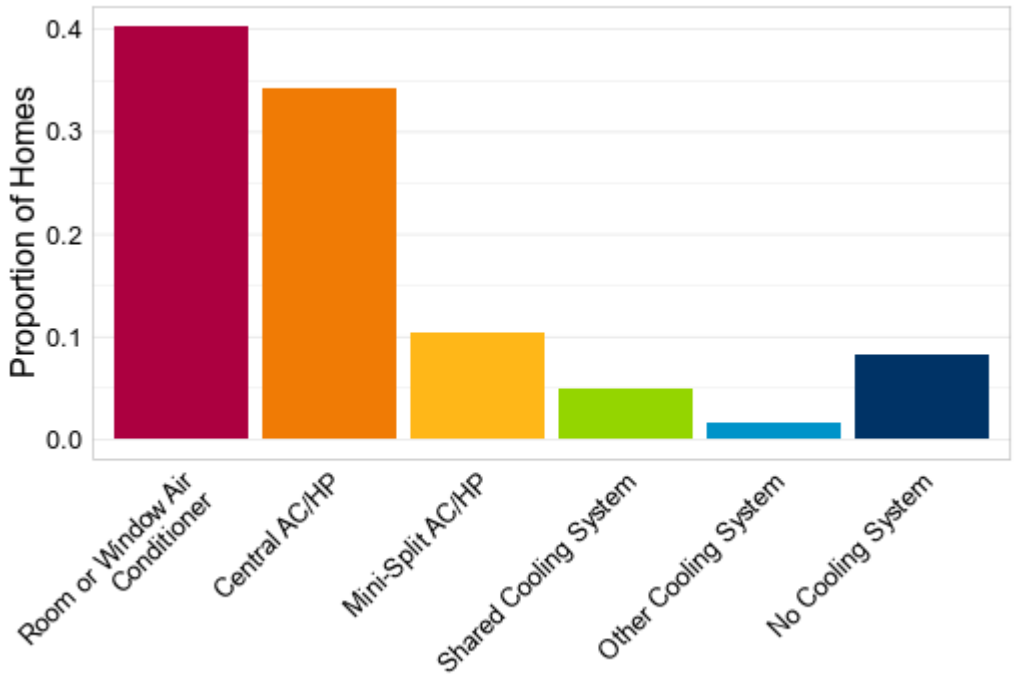
Figure 3-4. HVAC Cooling Equipment Saturation Trends



Source: Guidehouse analysis

Figure 3-5 shows the prevalence of end uses that were identified as the primary cooling system for the home. Room/window air conditioners dominate household cooling, followed by central systems, while mini-splits and other options remain less common. A small but significant portion of homes lacks any cooling system.

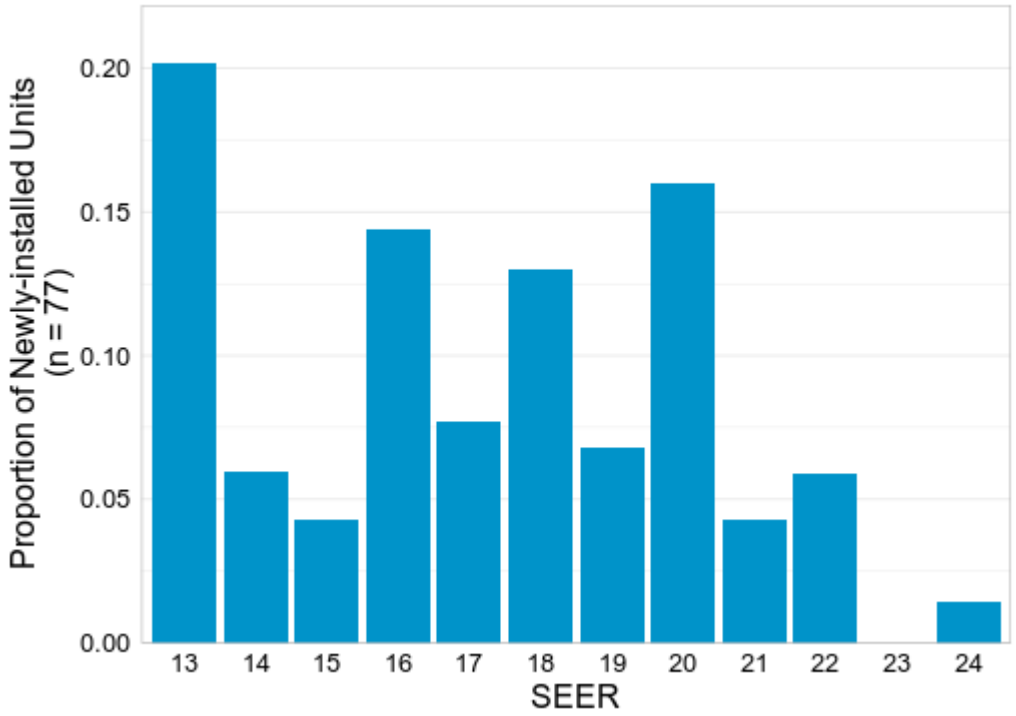
Figure 3-5. Primary Cooling System Saturation



Source: Guidehouse analysis

Figure 3-6. illustrates the distribution of seasonal energy efficiency ratio(SEER) ratings among newly installed central air conditioning/heat pump units.[11] Overall, the results suggest that while many consumers continue to select standard efficiency models, there is growing uptake of advanced, high-efficiency systems.

Figure 3-6. New Central Air Conditioning/Heat Pump Efficiencies

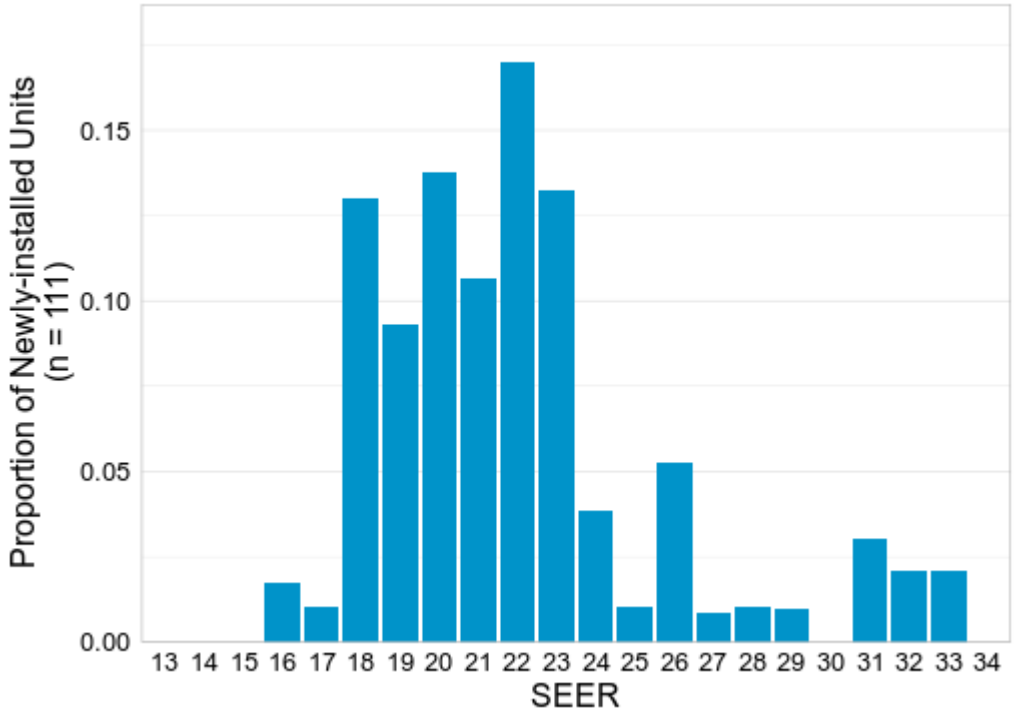


Source: Guidehouse analysis

[11] New U.S. Department of Energy regulations for air conditioner condensing units and heat pumps went into effect in 2023. These regulations require manufacturers to report new versions of efficiency metrics (SEER 2, EER 2, and HSPF 2). The figures in this report use older efficiency metrics because most of the end uses were manufactured prior to the new regulation going into effect.

Figure 3-7 displays the distribution of SEER ratings among newly installed mini-split air conditioning/heat pump units. The results indicate that most new equipment installations favor high-efficiency systems, with a significant portion of units meeting or exceeding SEER 20.

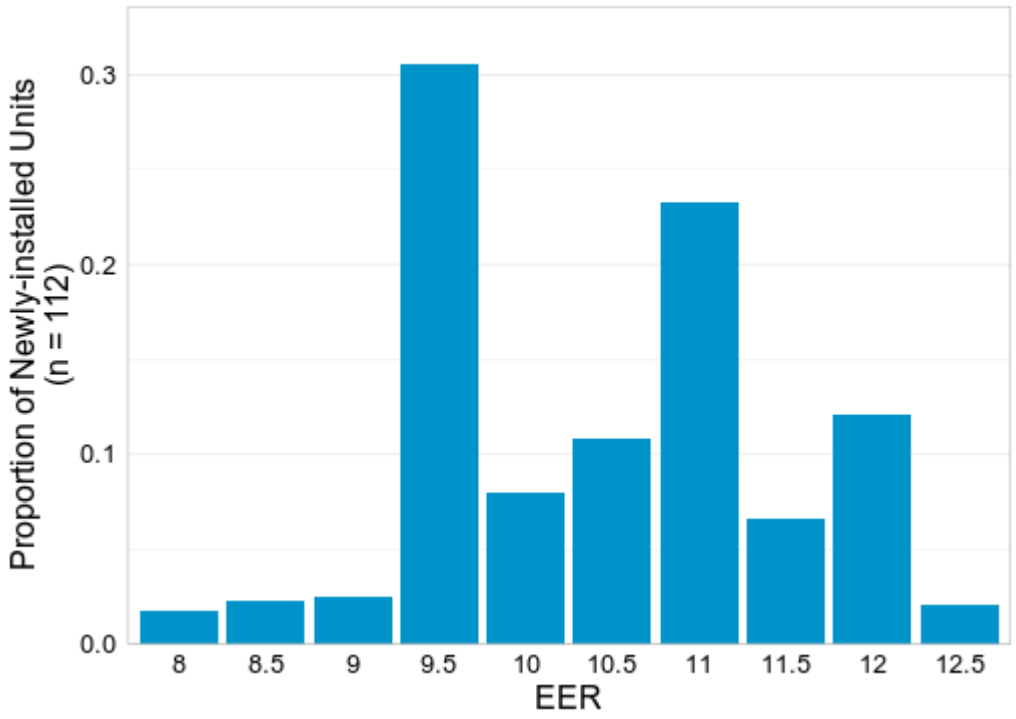
Figure 3-7. New Mini-Split Air Conditioner/Heat Pump Efficiencies



Source: Guidehouse analysis

Figure 3-8 and Figure 3-9 show efficiencies of new room air conditioners.[12] Because room air conditioner standard efficiencies are variable, making the figure of absolute efficiencies difficult to interpret, a histogram of new room air conditioner efficiencies as a ratio of the relevant standard efficiency is included in Figure 3-10. Very few units exceed 1.30, and almost none fall below 0.90, suggesting limited adoption of very low or very high efficiency units. Most installed units meet or slightly exceed code minimum efficiency, with a smaller but notable share achieving higher performance levels.

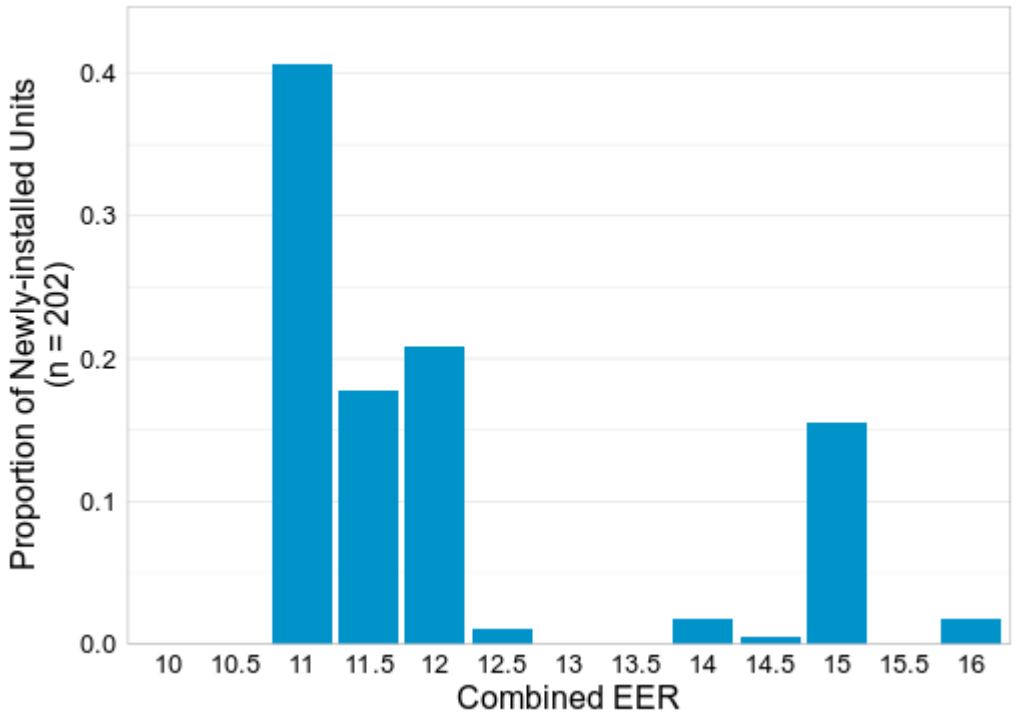
Figure 3-8. New Room/Window Air Conditioner Efficiencies (EER)



Source: Guidehouse analysis

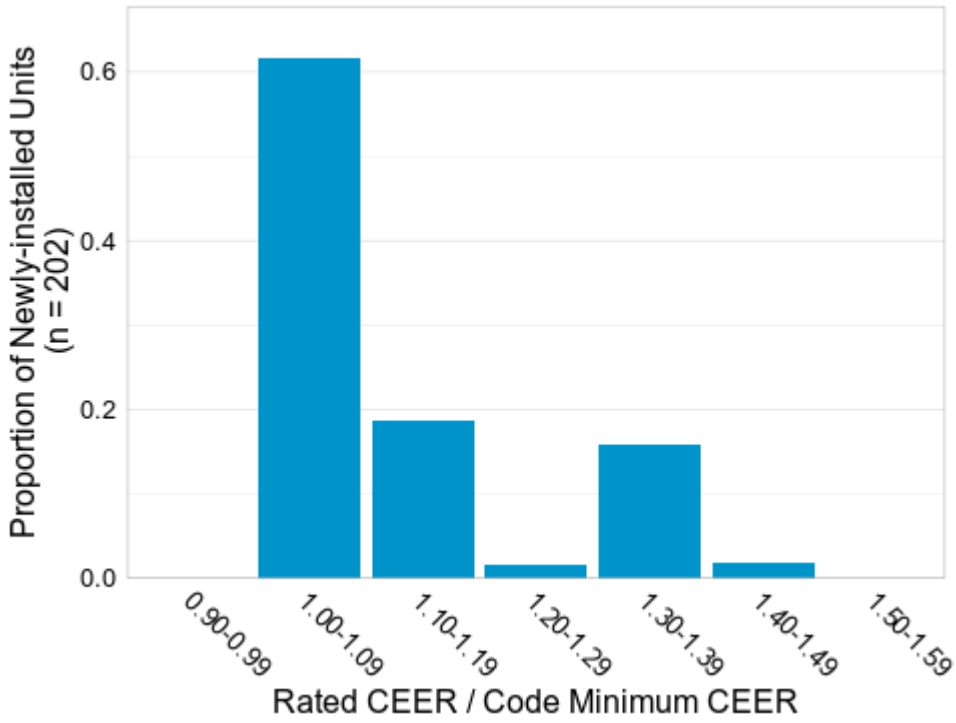
[12] The U.S. Department of Energy standard for room air conditioners took effect in 2014. The standards require manufacturers to report combined energy efficiency ratio (CEER). CEER was introduced to account for the standby power usage of room air conditioners.

Figure 3-9. Existing and New Room/Window Air Conditioner Efficiencies (CEER)



Source: Guidehouse analysis

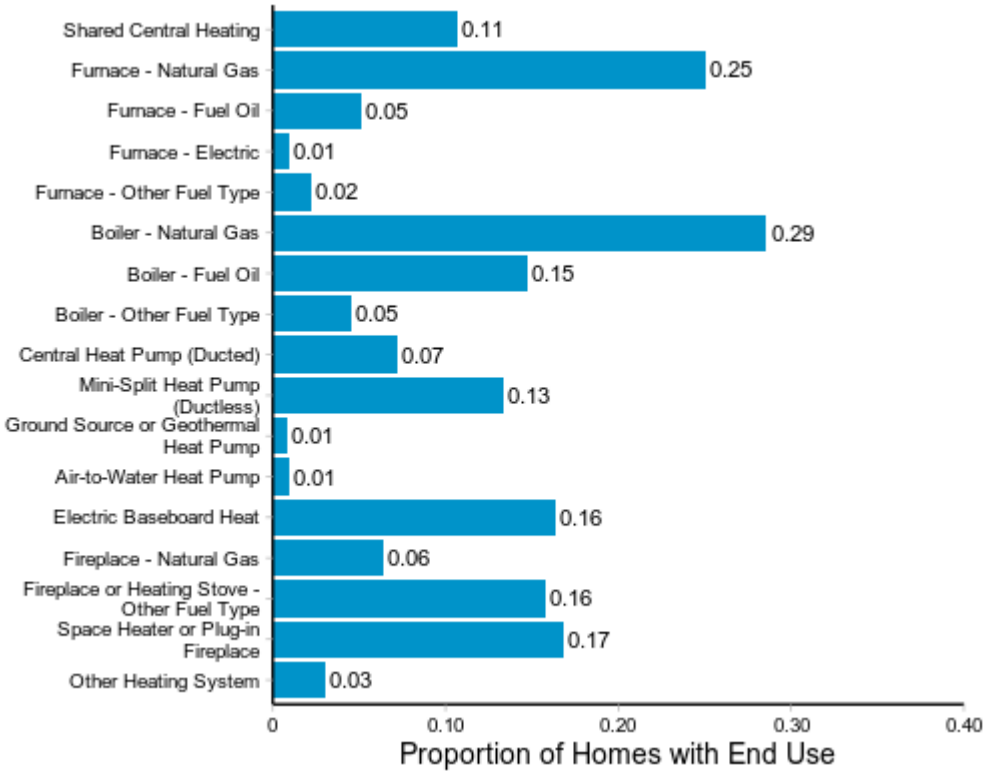
Figure 3-10. New Room/Window Air Conditioner Efficiencies as a Ratio of Code Minimum Efficiency



Source: Guidehouse analysis

Figure 3-11 displays the distribution of heating system types by the proportion of homes using each end use category. The data shows that boilers fueled by natural gas represent the largest share at 29%, followed by furnaces using natural gas at 25%.

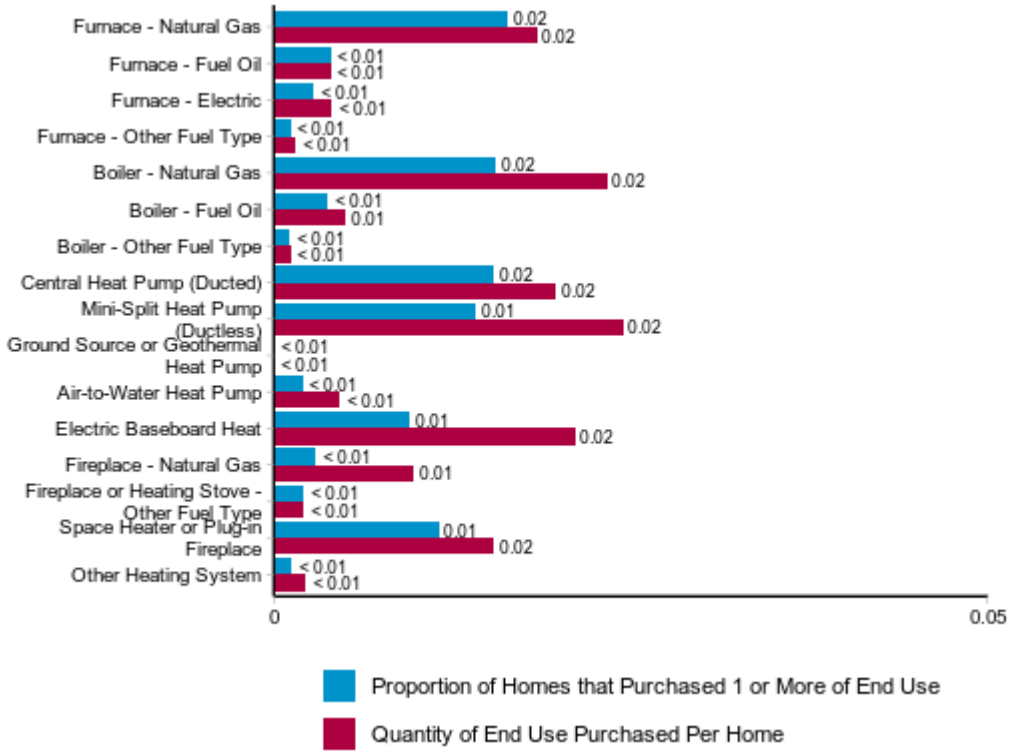
Figure 3-11. HVAC Heating Equipment Saturation



Source: Guidehouse analysis

Figure 3-12 shows purchases of heating systems, comparing the proportion of homes that bought at least one unit (blue bars) and the average quantity purchased per home (red bars).

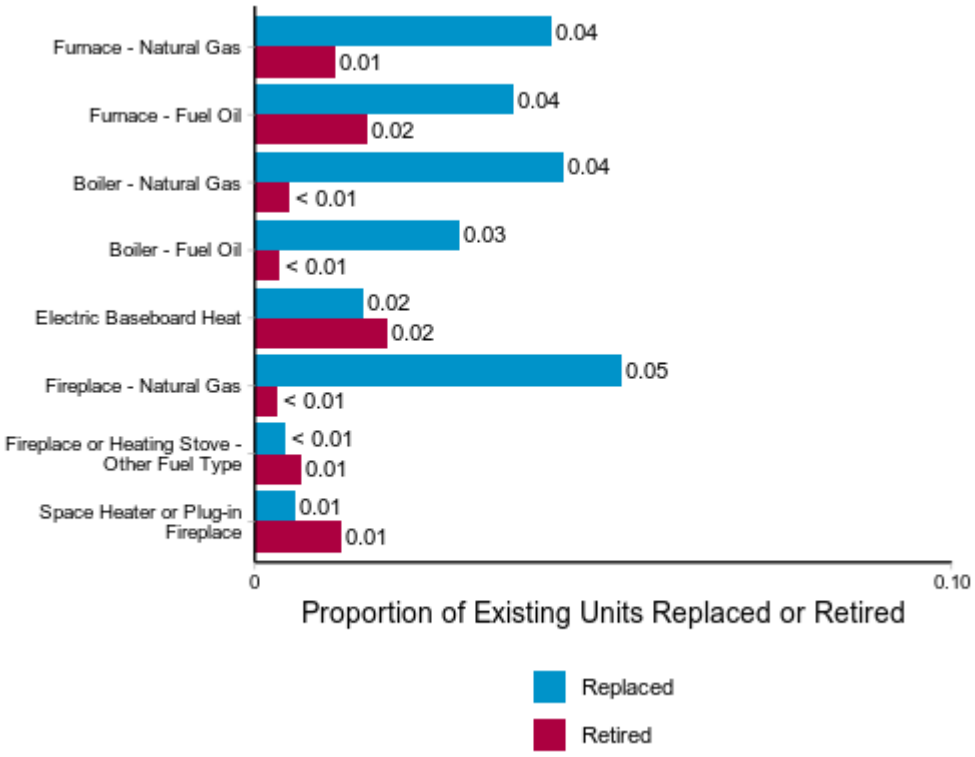
Figure 3-12. Proportion of Homes that Purchased Heating Season HVAC End Uses in the Past Year



Source: Guidehouse analysis

Figure 3-13 illustrates replacement and retirement of existing heating units. Purchases and replacements are concentrated in traditional systems such as natural gas furnaces and boilers, while heat pumps and other alternatives show minimal activity. Retirement rates are low, suggesting gradual turnover rather than rapid system change.

Figure 3-13. Proportion of Existing Heating Season HVAC Units Replaced or Retired in the Past Year

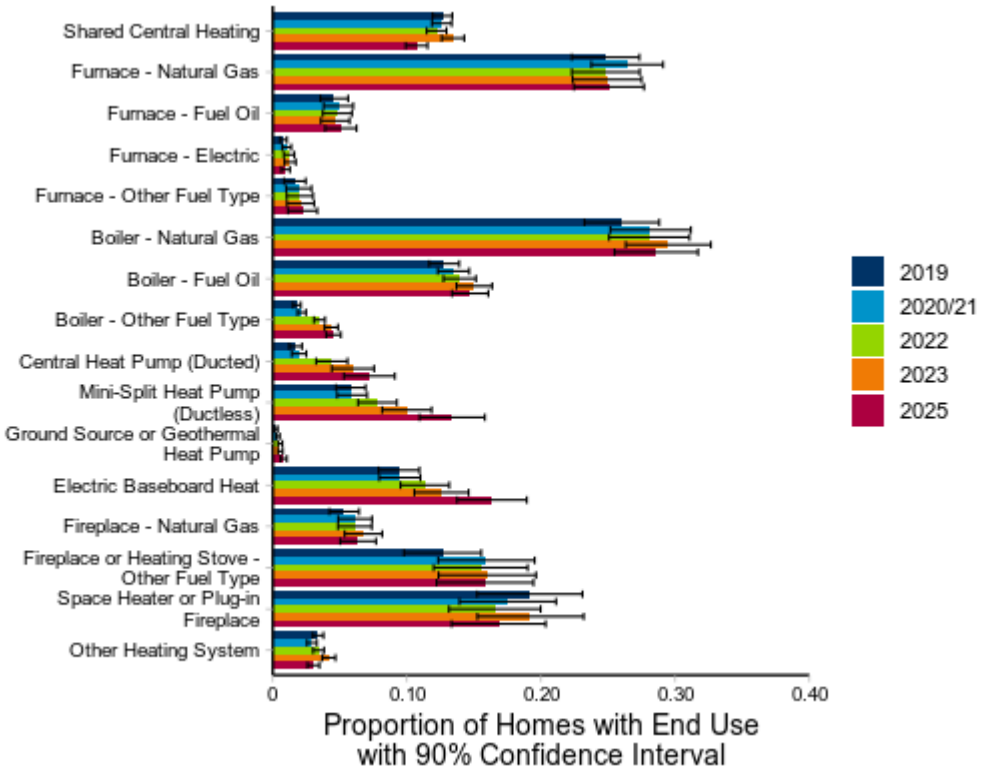


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-14 illustrates trends in heating system saturation from 2018 to 2025, with 90% confidence intervals for each estimate.[13] Natural gas furnaces and boilers remain the dominant heating systems across all years, but there is a clear upward trend in electric-based heating and heat pump adoption.

Figure 3-14. HVAC Heating Equipment Saturation Trends

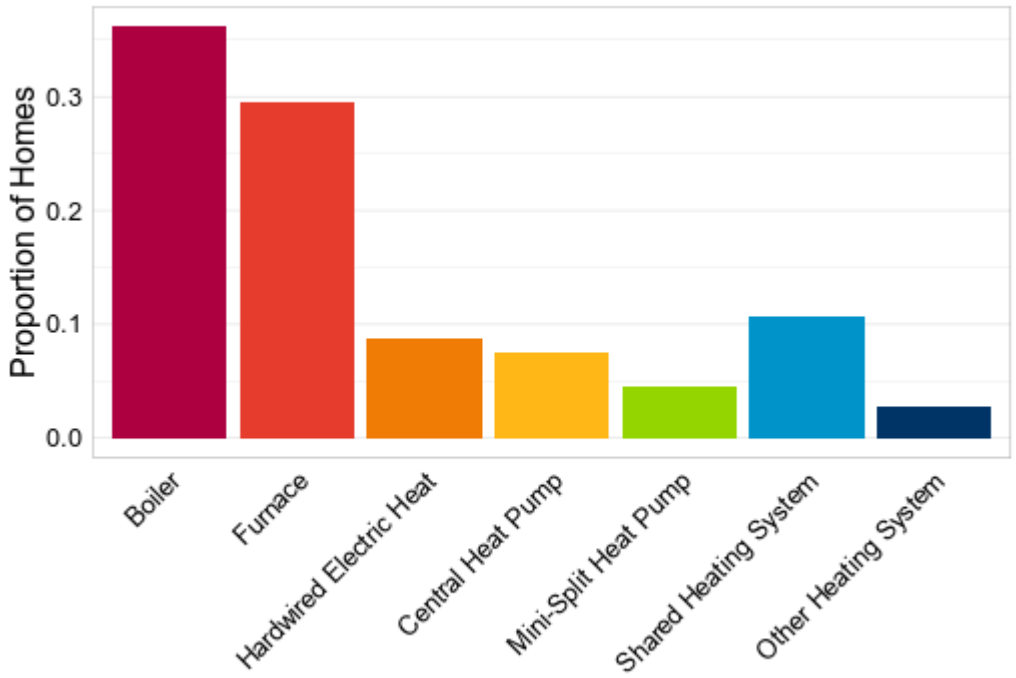


Source: Guidehouse analysis

[13] The team identified a limitation in the methodology used to derive gas and oil saturation. The proportion of survey respondents with gas service might not be the same as the statewide proportion of customers with gas service. The team added a survey question to try to correct for this limitation in this phase, but the data quality was not sufficient to apply a quantitative adjustment.

Figure 3-15 shows the proportion of homes by primary heating system type. Traditional systems such as boilers and furnaces dominate home heating, while heat pumps and other alternatives represent a smaller but growing share.

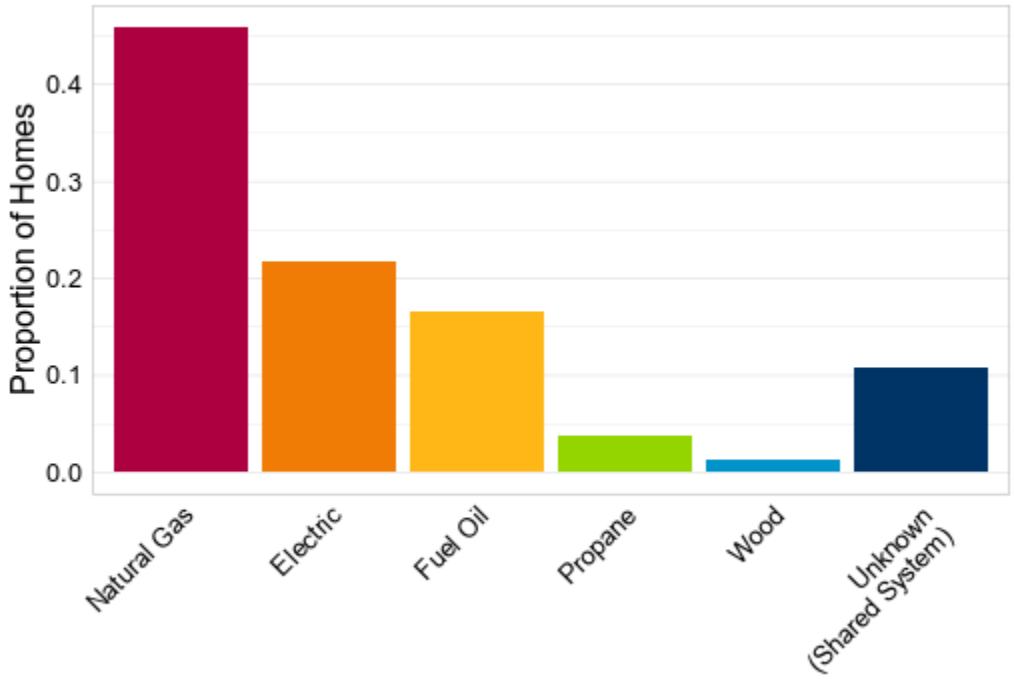
Figure 3-15. Primary Heating System Type



Source: Guidehouse analysis

Figure 3-16 shows the distribution of primary heating system fuel type. Natural gas is the most common heating fuel in Massachusetts homes, followed by electric and fuel oil systems. Fuel type information was not gathered for homes with shared central heating systems (for which the customer may not know the fuel type); these homes are marked as unknown.

Figure 3-16. Primary Heating System Fuel



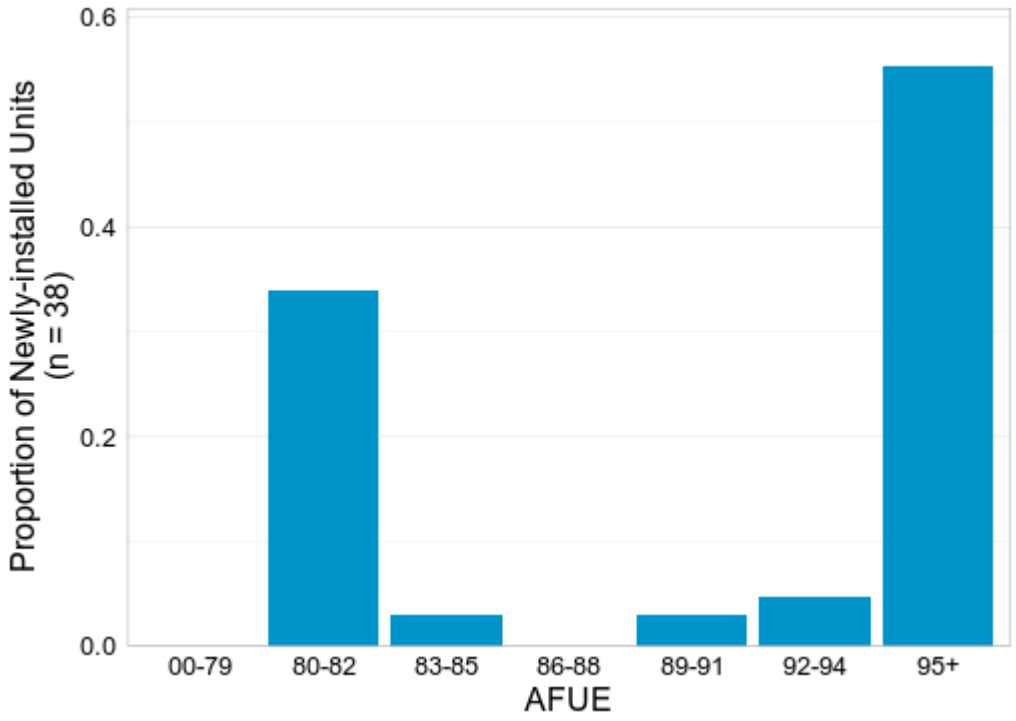
Source: Guidehouse analysis

Figure 3-17 and Figure 3-18 show the distribution of annual fuel utilization efficiency (AFUE) ratings for newly installed gas furnaces and boilers. The residential gas furnace market is bimodal, with roughly half of installations falling into the lower-efficiency, non-condensing tier and the other half in the higher-efficiency condensing tier. This split reflects continued reliance on legacy, lower efficiency systems even as a growing segment of houses adopts high-efficiency equipment.

The persistence of low-efficiency installations underscores both the scale of the remaining retrofit opportunity and the practical barriers that may limit the uptake of condensing units. Installing a condensing furnace or boiler in a home not previously equipped for one may require condensate line installation or upgrades, PVC venting, or other modifications that increase project complexity and cost. These installation constraints may be a factor in the continued prevalence of non-condensing systems despite the availability of higher-efficiency options.

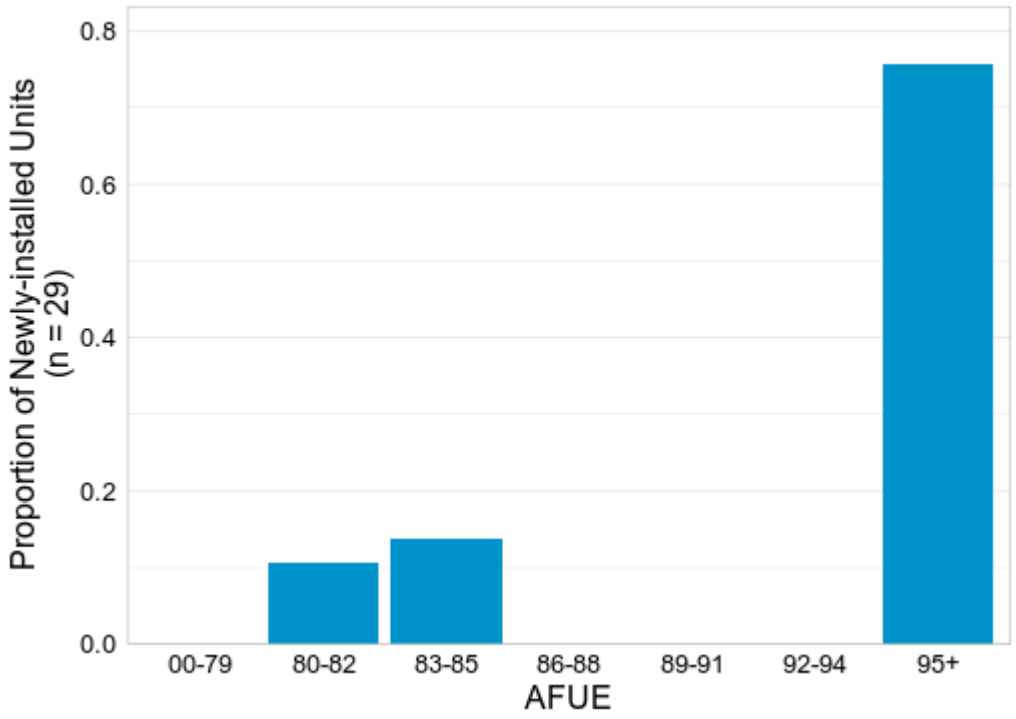
Proportions of units installed broken out by household demographics can be found in Appendix B.

Figure 3-17. New Gas Furnace Efficiencies



Source: Guidehouse analysis

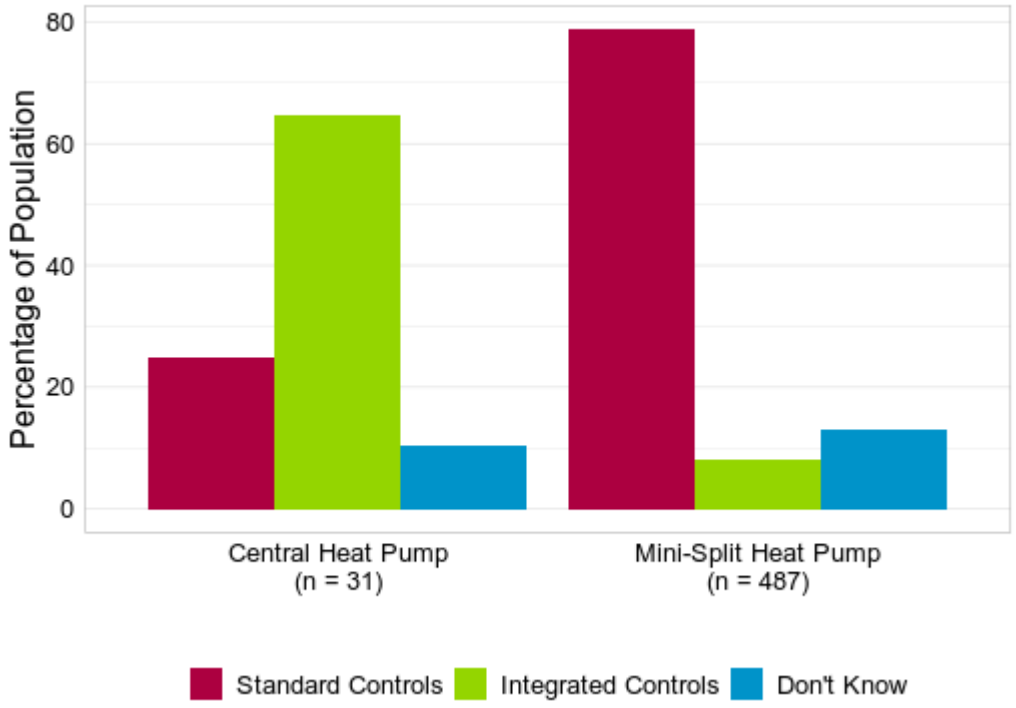
Figure 3-18. New Gas Boiler Efficiencies



Source: Guidehouse analysis

Figure 3-19 shows the survey self-reported control types for customers with installed central heat pumps or mini-split heat pumps. About 65% of customers with central heat pumps and 8% of customers with mini-split heat pumps report using integrated controls for their heat pumps, which automatically switch from heating with the heat pump to a conventional fuel-fired furnace or boiler at a pre-selected temperature.

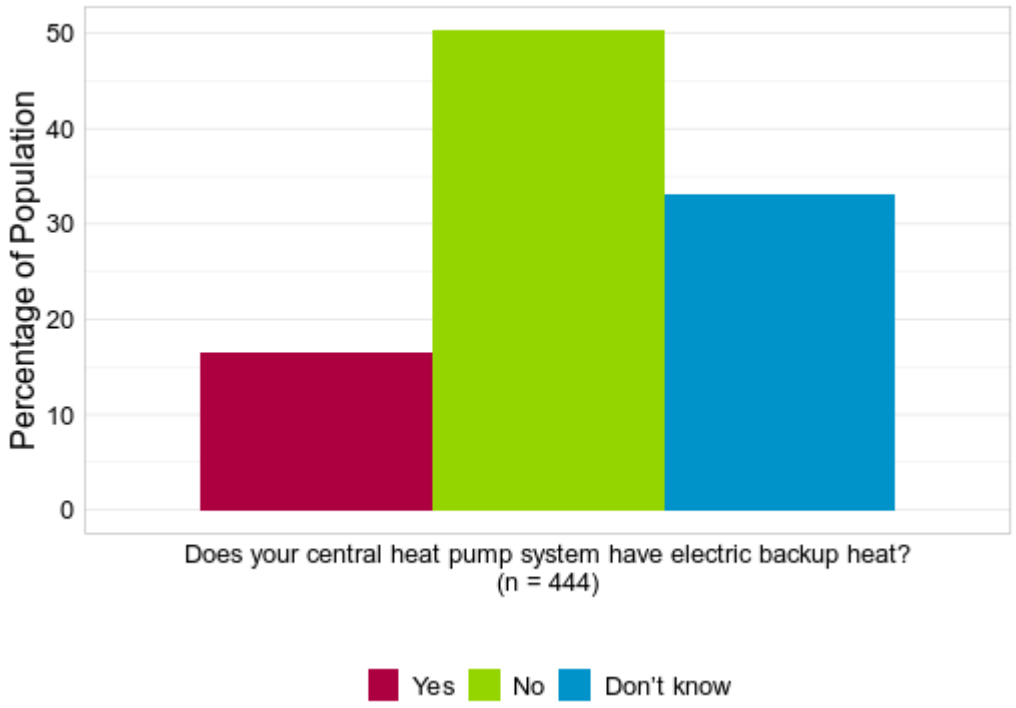
Figure 3-19. Self-Reported Heat Pump Control Type



Source: Guidehouse analysis

Figure 3-20. shows that nearly half of respondents report their central heat pump does not have electric backup heat, while only 16% say it does, and around 34% are unsure.

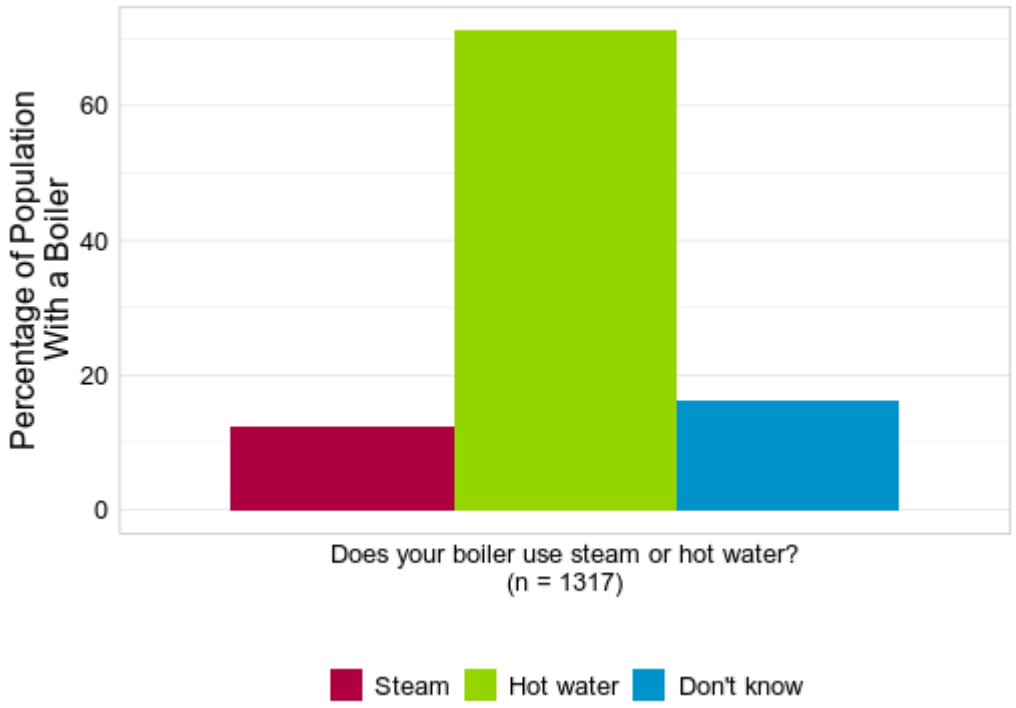
Figure 3-20. Heat Pump System Integrated Backup Heat



Source: Guidehouse analysis

Figure 3-21 shows that most respondents (around 72%) report that their boiler uses hot water, while only about 12% say it uses steam, and roughly 16% are unsure. This finding indicates that hot water systems dominate, but a notable portion of the population does not know their boiler type.

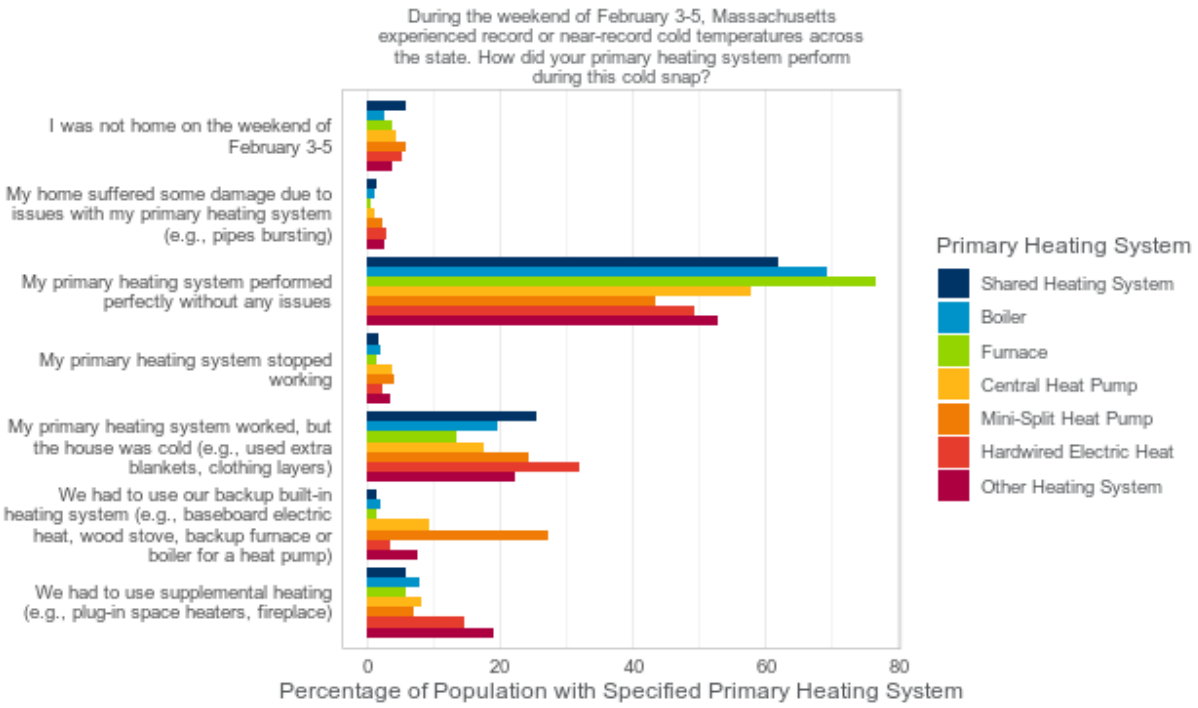
Figure 3-21. Steam vs. Hot Water Boiler



Source: Guidehouse analysis

Figure 3-22. shows that during the February 3-5, 2023 cold snap in Massachusetts, heat pumps were significantly more likely to experience performance issues than boilers and furnaces. Almost 30% of those that have a mini-split heat pump as their primary heating system reported using backup heat during the event.

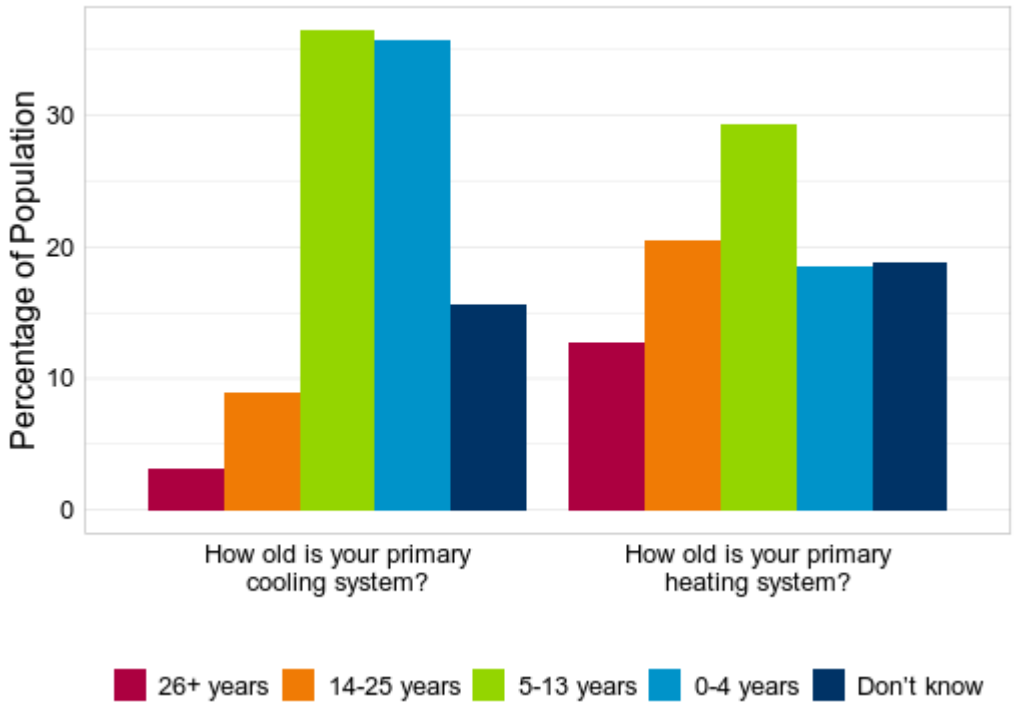
Figure 3-22. Primary Heating System Performance During Cold Snap



Source: Guidehouse analysis

Figure 3-23 shows that most primary cooling systems are relatively new or mid-aged.

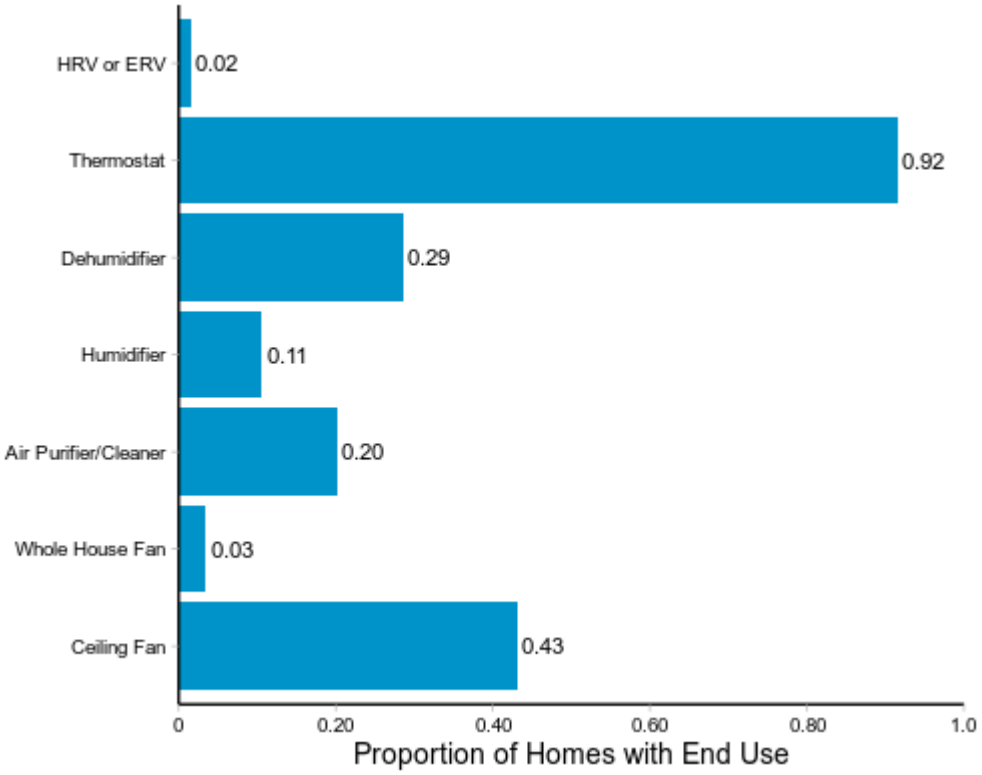
Figure 3-23. Primary HVAC System Ages



Source: Guidehouse analysis

Figure 3-24. shows the proportion of homes equipped with various end use devices. Thermostats are nearly universal, while advanced ventilation systems and whole-house fans remain niche. Ceiling fans and dehumidifiers show moderate adoption.

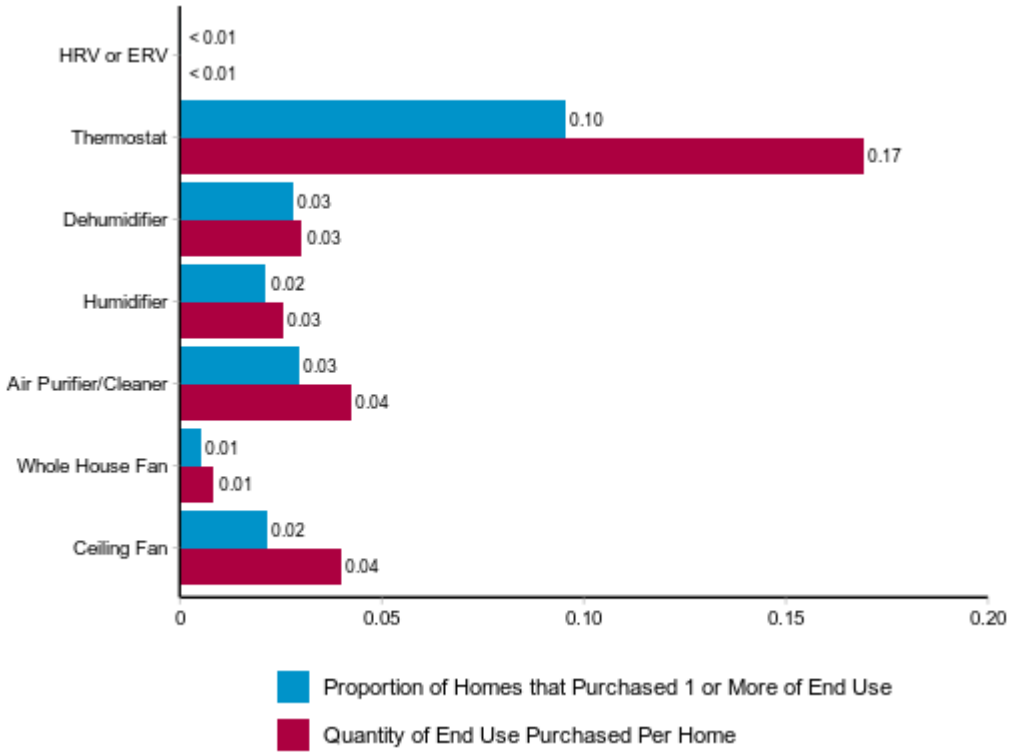
Figure 3-24. Miscellaneous HVAC Equipment Saturation



Source: Guidehouse analysis

Figure 3-25 and Figure 3-26 show the proportion of homes that purchased new equipment and the proportion of removed equipment in the miscellaneous HVAC category. In Figure 3-25., thermostats dominate new purchases, with 10% of homes buying at least one and an average of 0.17 units per home, far exceeding other categories. Dehumidifiers and air purifiers/cleaners follow at 3% each, while humidifiers and ceiling fans account for 2% of homes. Whole-house fans and Heat Recovery Ventilator or Energy Recovery Ventilator (HRV/ERV) systems remain niche, with less than 1% adoption.

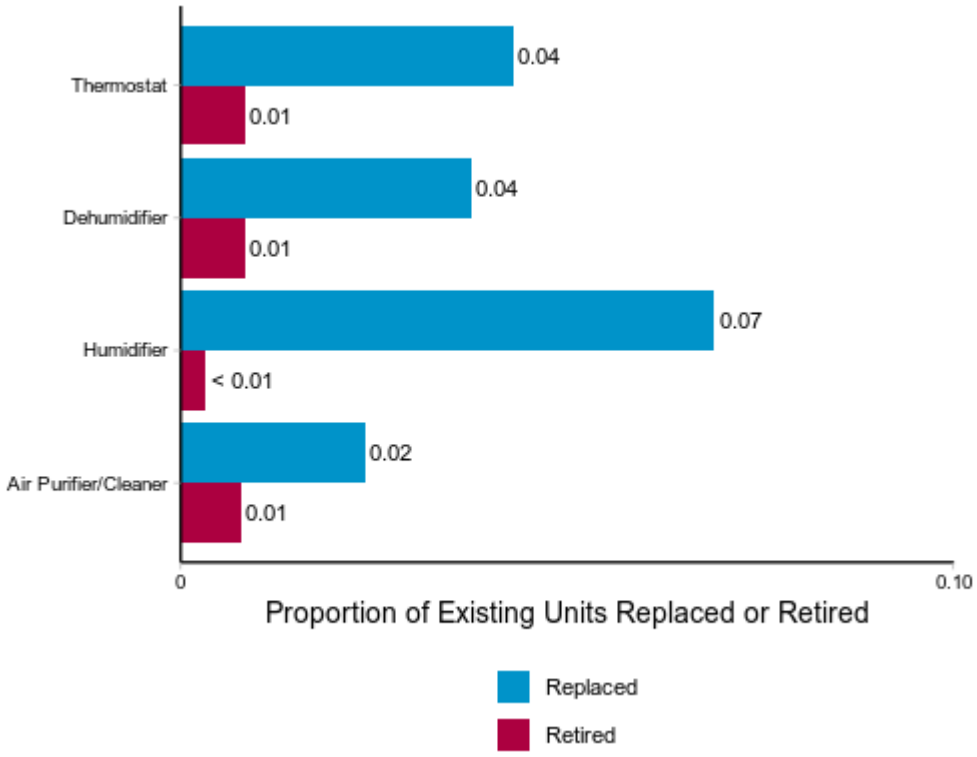
Figure 3-25. Proportion of Homes that Purchased New Miscellaneous HVAC Equipment in the Past Year



Source: Guidehouse analysis

In Figure 3-26, humidifiers lead at 7%, while thermostats and dehumidifiers follow at 4% and air purifiers at 2% for replacement rates. Retirement rates are consistently low across all categories, around 1%.

Figure 3-26. Proportion of Existing Miscellaneous HVAC Units Replaced or Retired in the Past Year

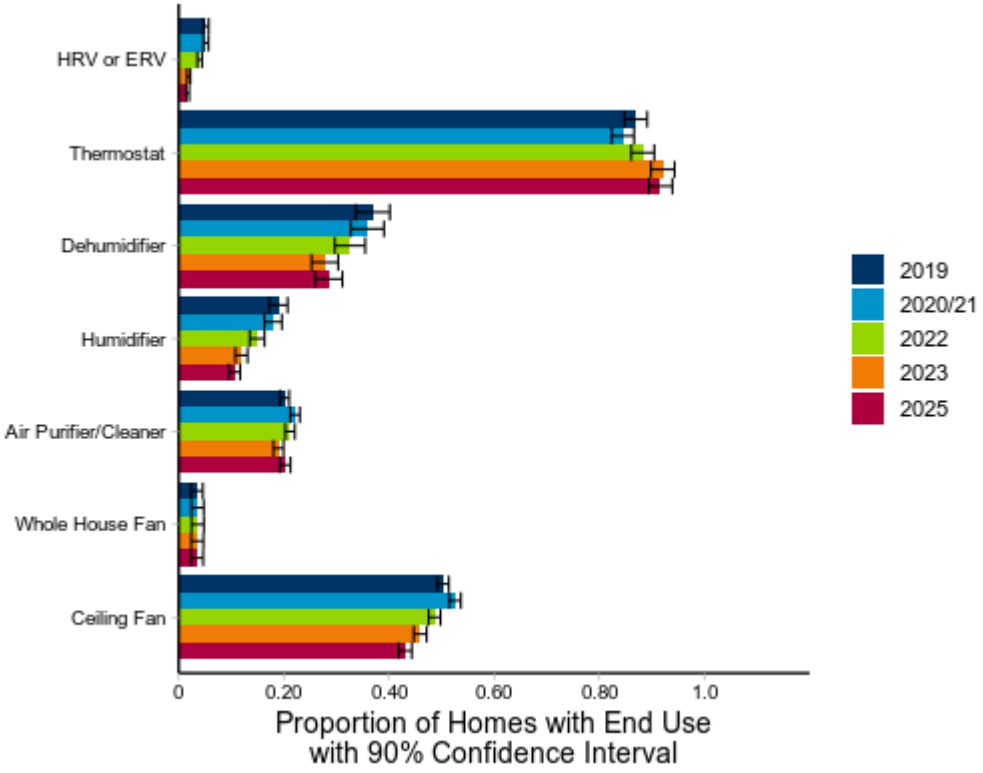


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-27. shows the proportion of homes with various end use devices from 2018 through 2025.

Figure 3-27. Miscellaneous HVAC Equipment Saturation Trends[14][15]



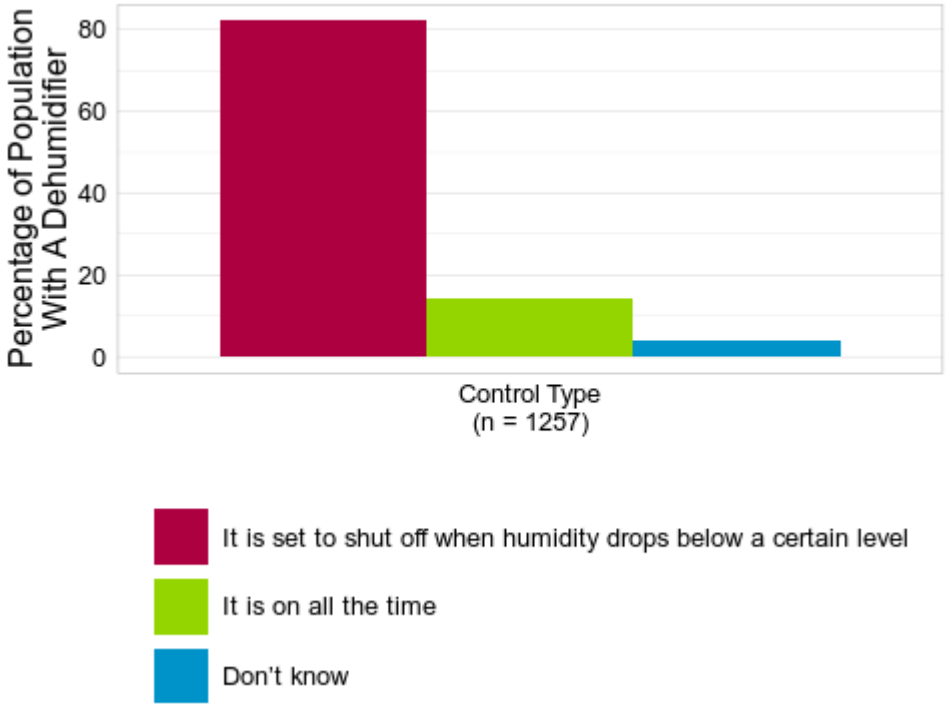
Source: Guidehouse analysis

[14] HRVs, also known as ERVs, are systems for providing ventilation while recovering residual heat in the exhaust air.

[15] The decrease in HRV, dehumidifier, humidifier, and ceiling fan saturation might be in part due to respondents not entering complete data. See Appendix A for further details.

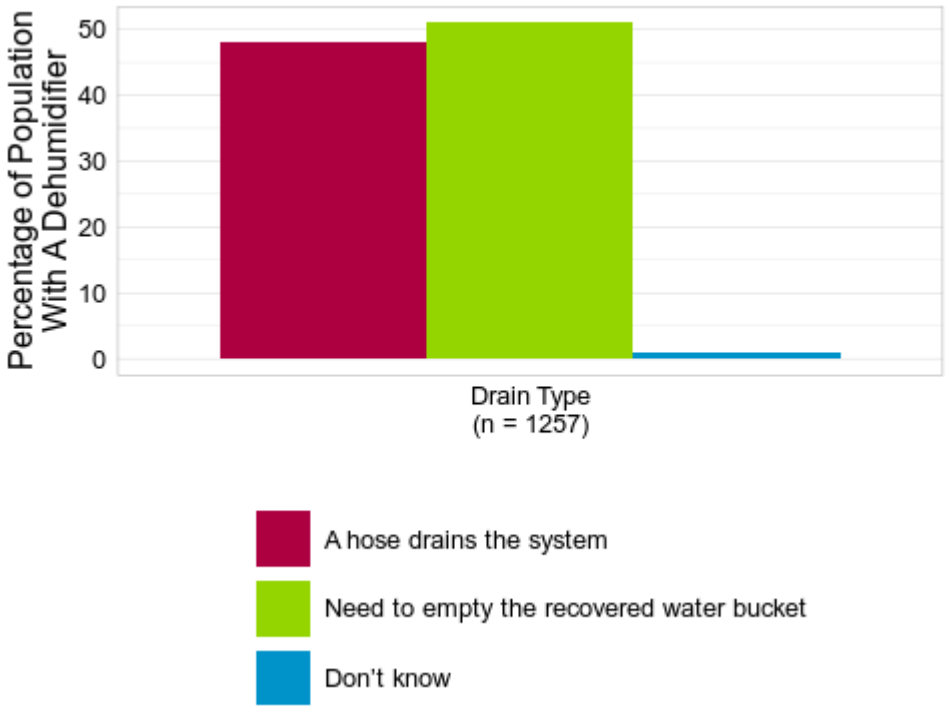
Figure 3-28. and Figure 3-29. show the survey self-reported control types and drain types for customers with dehumidifiers.

Figure 3-28. Self-Reported Dehumidifier Control Type



Source: Guidehouse analysis

Figure 3-29. Self-Reported Dehumidifier Drain Type

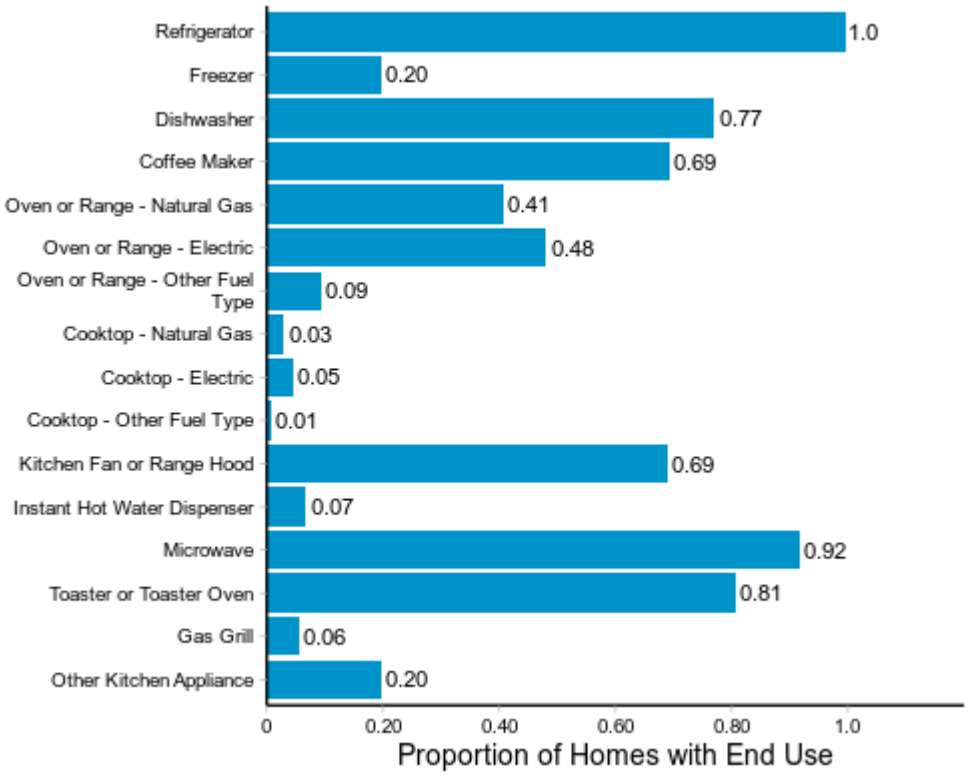


Source: Guidehouse analysis

3.2 Kitchen End Uses

Figure 3-30 shows the current saturation of kitchen end uses. Refrigerators, microwaves, and toasters dominate kitchen appliance ownership, while cooktops and specialty appliances remain uncommon.

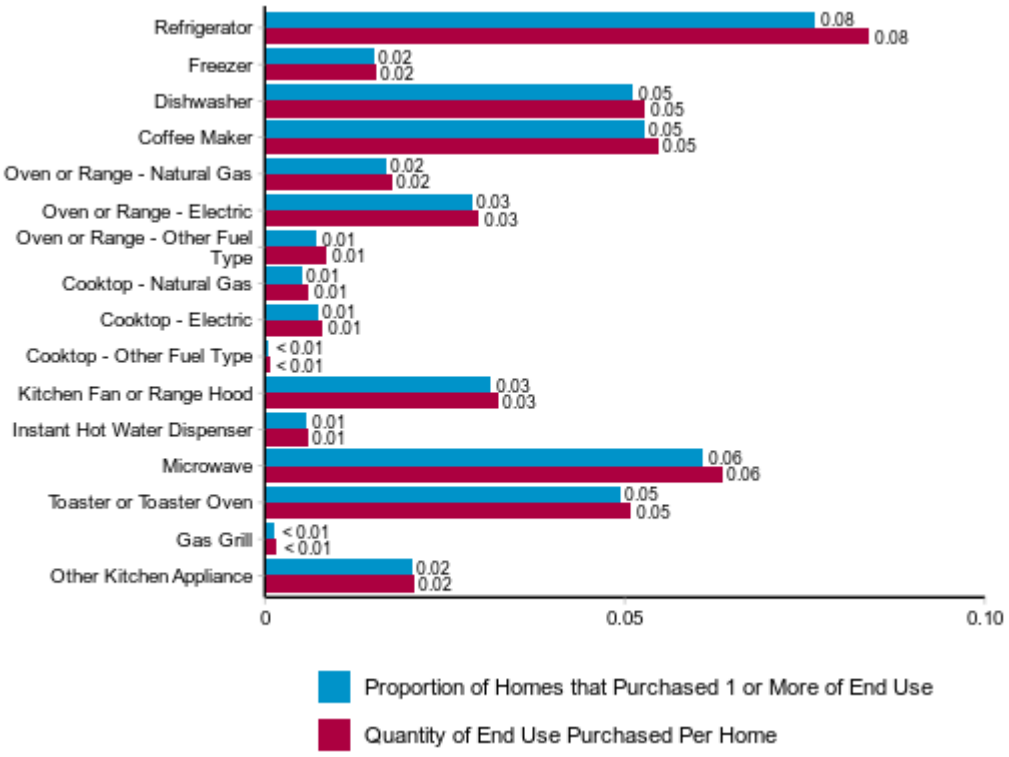
Figure 3-30. Kitchen End Use Saturation



Source: Guidehouse analysis

Figure 3-31 shows purchases of kitchen appliances, comparing the proportion of homes that bought at least one unit (blue bars) and the average quantity purchased per home (red bars). Purchases are generally low across all categories, with refrigerators leading at about 8% of homes and 0.09 units per home, followed by microwaves (6%), dishwashers (5%), and toasters (5%). Other appliances such as ovens, coffee makers, and range hoods have smaller shares, while specialty items such as cooktops and gas grills are minimal (<0.01).

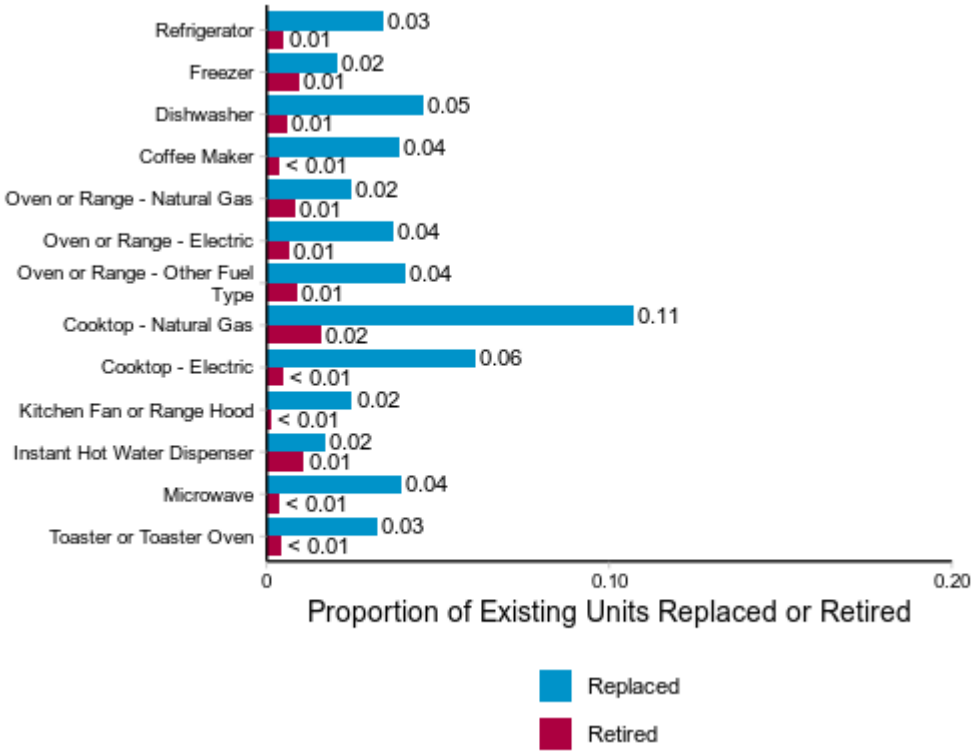
Figure 3-31. Proportion of Homes that Purchased New Kitchen End Uses in the Past Year



Source: Guidehouse analysis

Figure 3-32 illustrates replacement and retirement of existing kitchen appliances. Cooktops (natural gas) have the highest replacement rate (13%), followed by electric cooktops (6%) and electric ovens (4%). Other appliances, including refrigerators, microwaves, and dishwashers, show very low replacement and retirement activity (<0.05), indicating limited turnover for most categories.

Figure 3-32. Proportion of Existing Kitchen Units Replaced or Retired in the Past Year

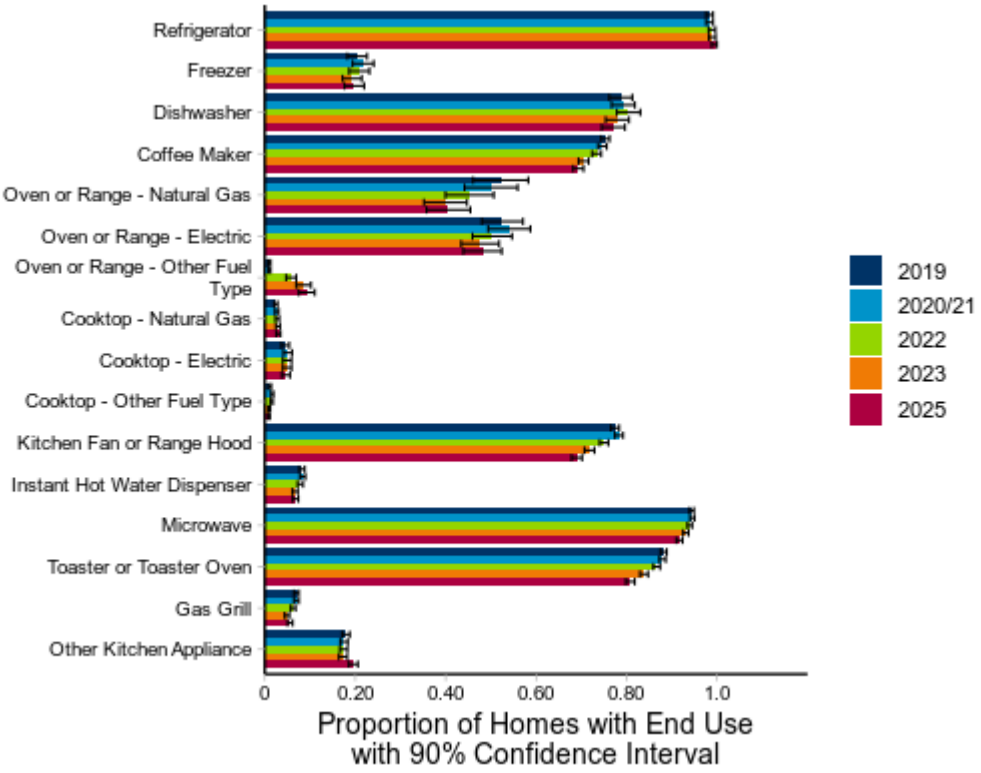


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-33. shows the trends in saturation between 2018 and 2025 for kitchen end uses. Most kitchen appliance saturations remain stable, but there are slight increases in electric ovens/ranges and microwaves, indicating continued preference for electric cooking and convenience appliances. Conversely, natural gas cooktops and ovens show a modest decline, suggesting a gradual shift away from gas in favor of electric options.

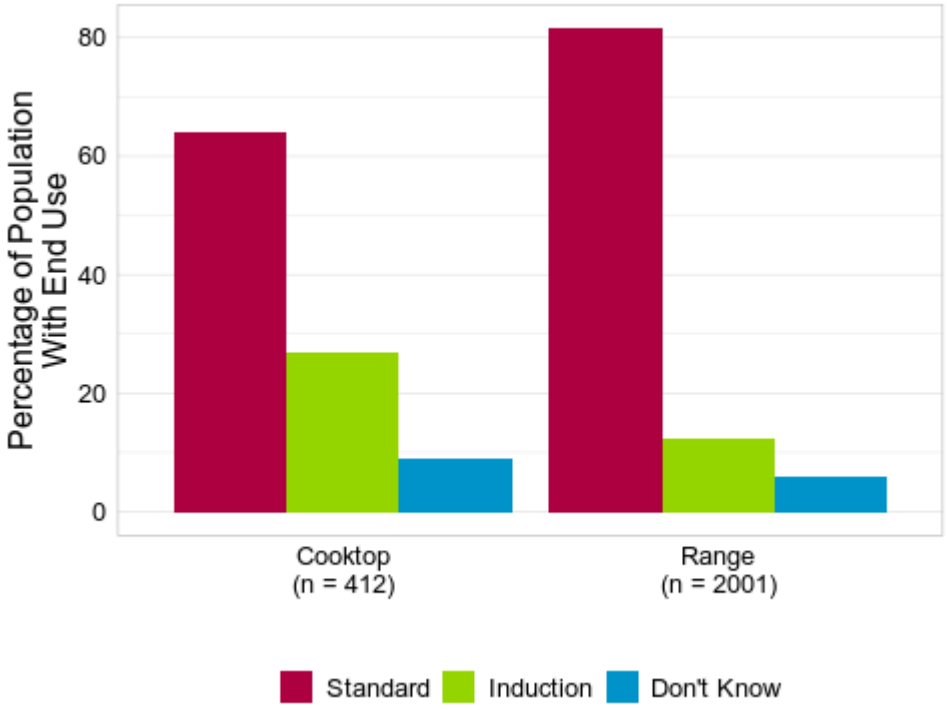
Figure 3-33. Kitchen End use Saturation Trends



Source: Guidehouse analysis

Figure 3-34 shows the percentage of electric cooktops and ranges that are standard and induction. Induction technology uses electromagnetic fields to directly heat the cookware rather than the cooktop surface. It is faster and more energy efficient than standard.

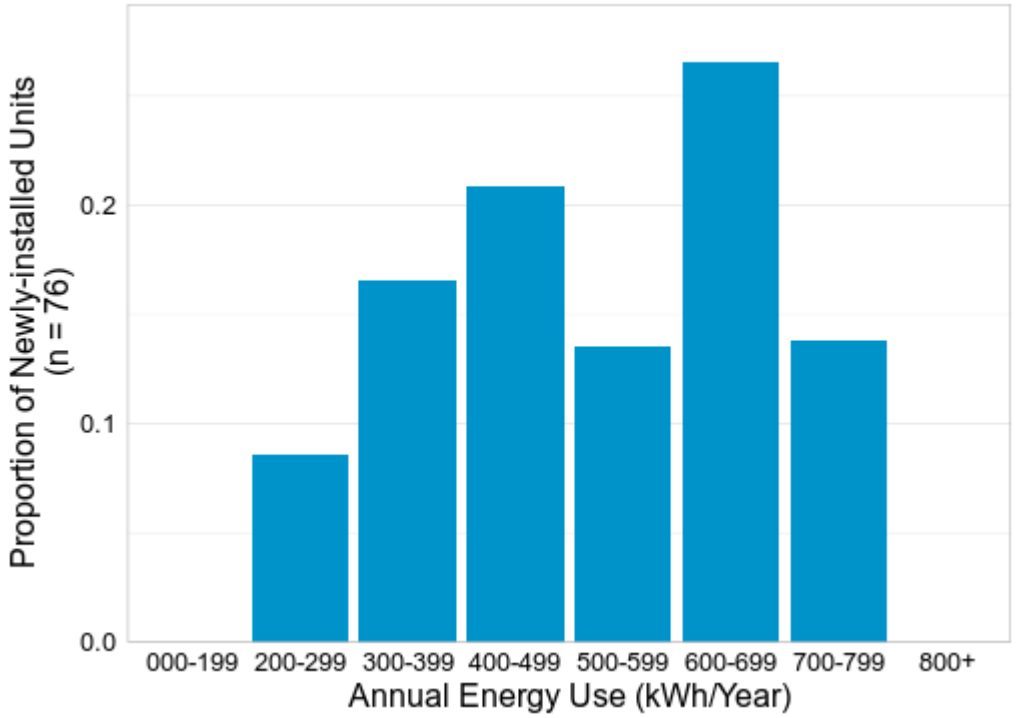
Figure 3-34. Electric Cooktop and Range Types



Source: Guidehouse analysis

Figure 3-35 shows the U.S. Department of Energy (DOE) estimated annual energy use for new primary refrigerators. Most units fall within the 400–699 kWh/year range, with the highest concentration in the 600–699 kWh/year bin (approximately 27%).

Figure 3-35. New Primary Refrigerator DOE-Estimated Annual Energy Use

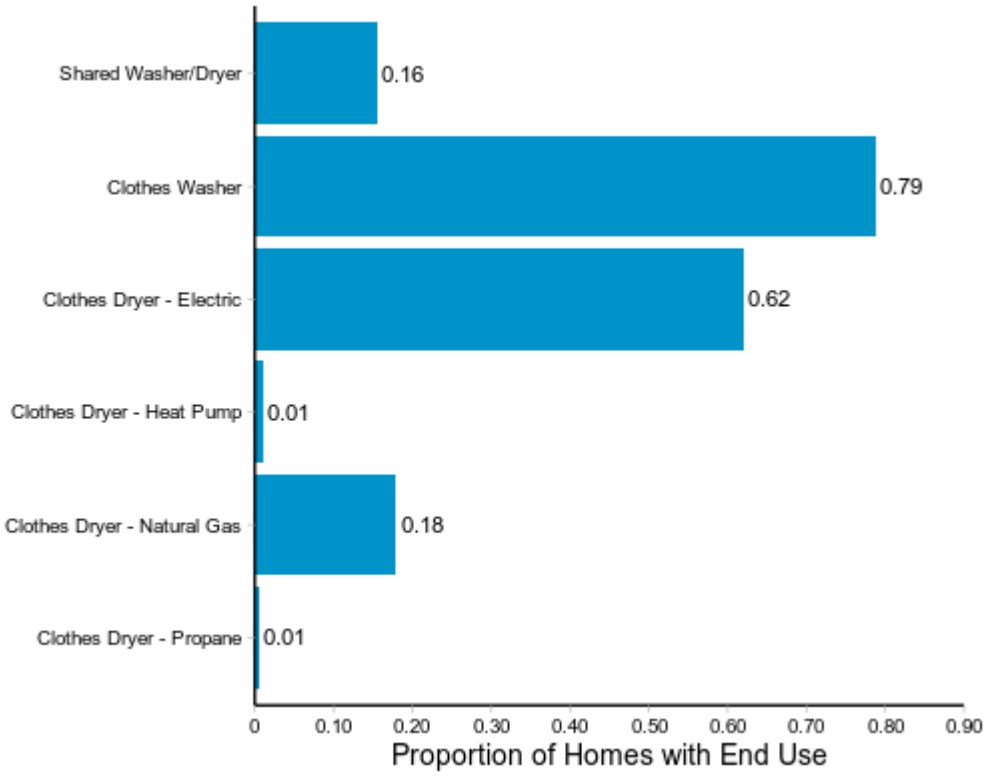


Source: Guidehouse analysis

3.3 Laundry End Uses

Figure 3-36 shows the distribution of laundry equipment in Massachusetts homes. Clothes washers and electric dryers dominate household laundry setups, while alternative dryer types (heat pump, propane) have negligible adoption.

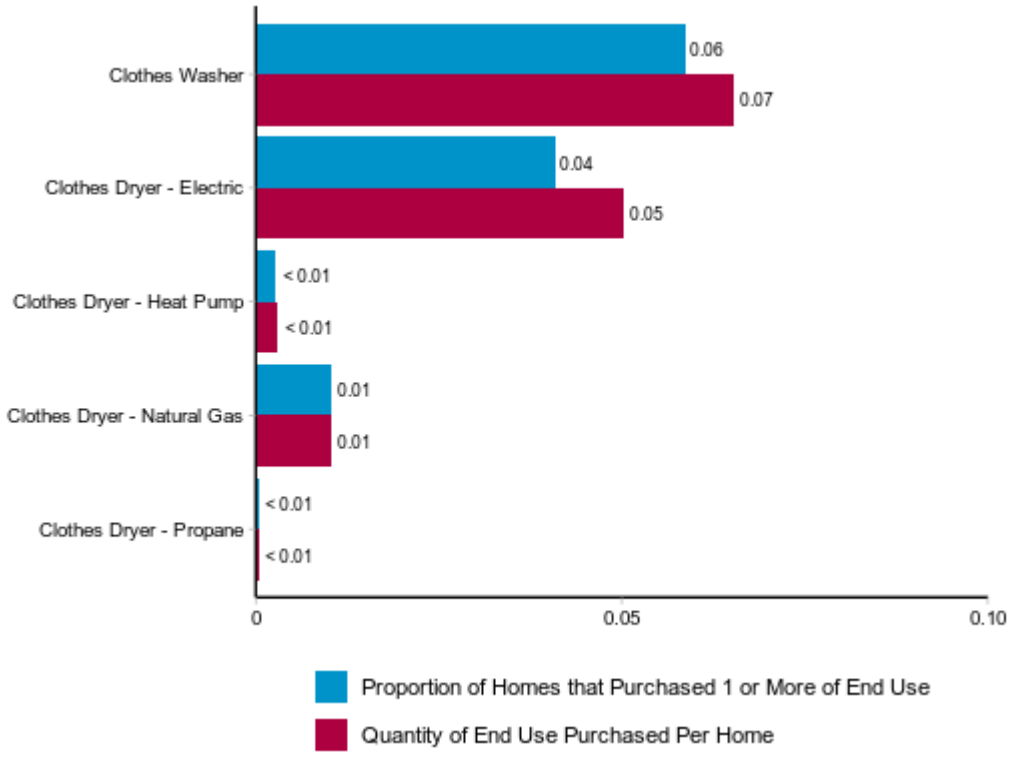
Figure 3-36. Laundry End Use Saturation



Source: Guidehouse analysis

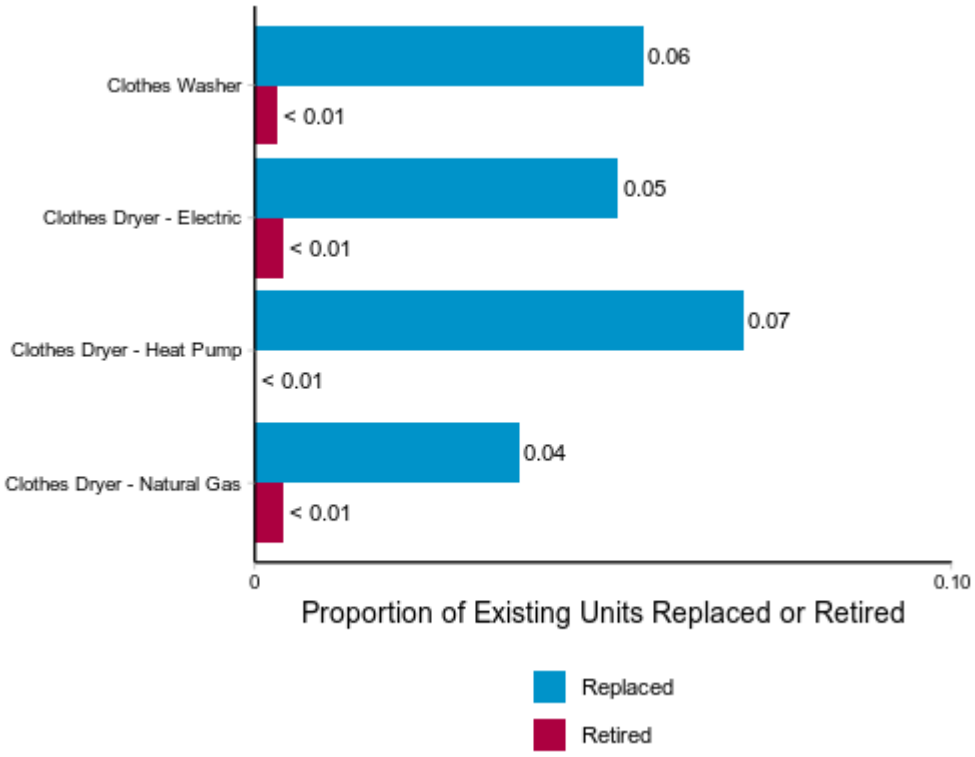
Figure 3-37 and Figure 3-38 support the change in saturation findings by showing the proportion of homes that purchased new laundry equipment and the proportion of existing laundry units replaced or retired in the past year, respectively. The market is dominated by washers and electric dryers, both in new purchases and replacements. Heat pump dryers, while rare in ownership, show significant replacement activity, signaling a potential trend toward energy efficient technologies. Retirement rates are negligible, meaning most changes are due to upgrades rather than discontinuation.

Figure 3-37. Proportion of Homes that Purchased New Laundry Equipment in the Past Year



Source: Guidehouse analysis

Figure 3-38. Proportion of Existing Laundry Units Replaced or Retired in the Past Year

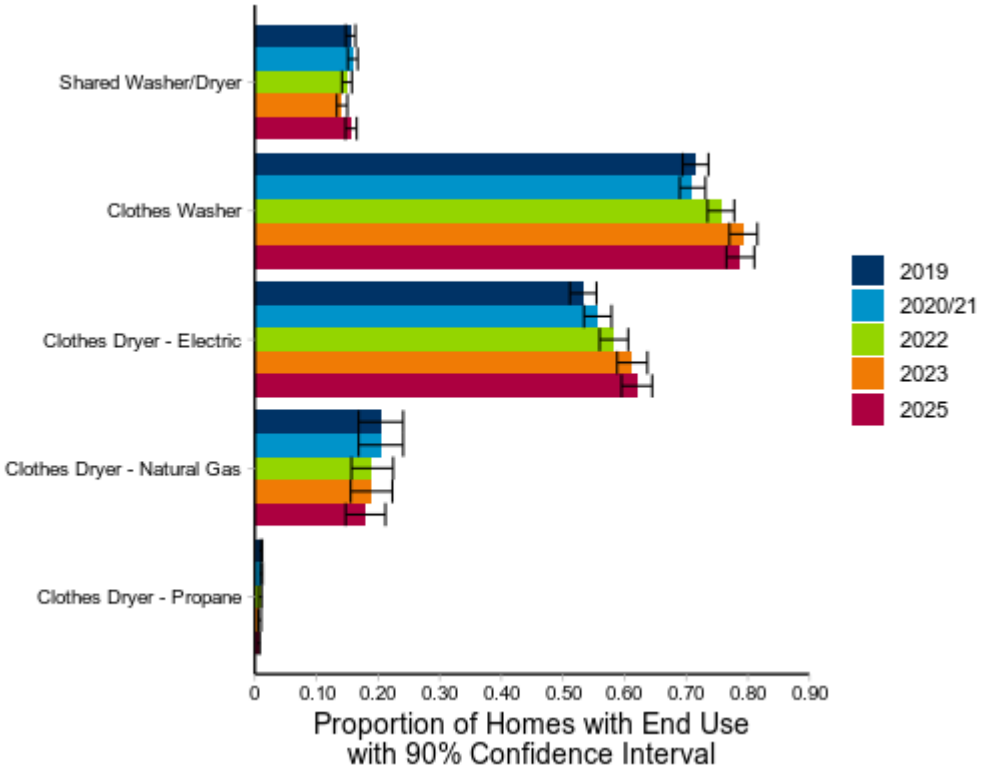


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-39 shows the trends in saturation between 2018 and 2025 for laundry end uses. Clothes washers and electric dryers exhibit a slight increase over time, while natural gas dryers show a modest decline, and shared washer/dryer units remain relatively stable.

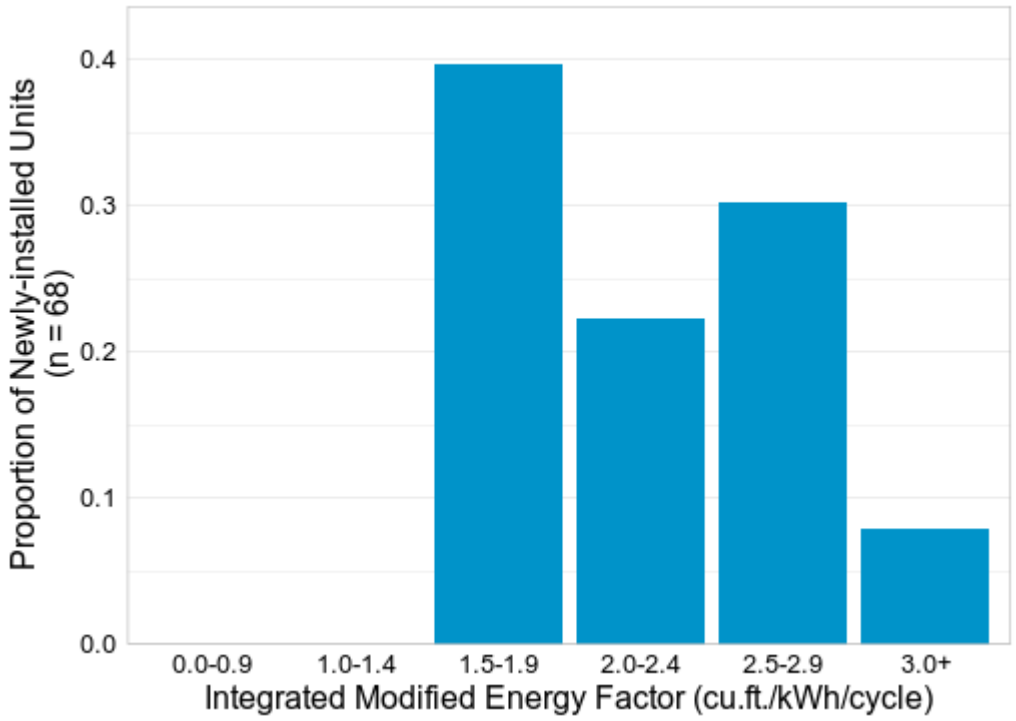
Figure 3-39. Laundry End use Saturation Trends



Source: Guidehouse analysis

Figure 3-40 shows a comparison of efficiencies for existing and newly installed clothes washers in Massachusetts by integrated modified energy factor (IMEF), measured in cubic feet per kilowatt-hour per cycle. The results suggest that most new installations of clothes washers cluster around mid-to-high efficiency performance, with limited adoption of ultra-high-efficiency units (IMEF ≥ 3.0). This trend reflects a strong preference for systems that balance energy savings with practical performance standards.

Figure 3-40. New Clothes Washer Efficiencies

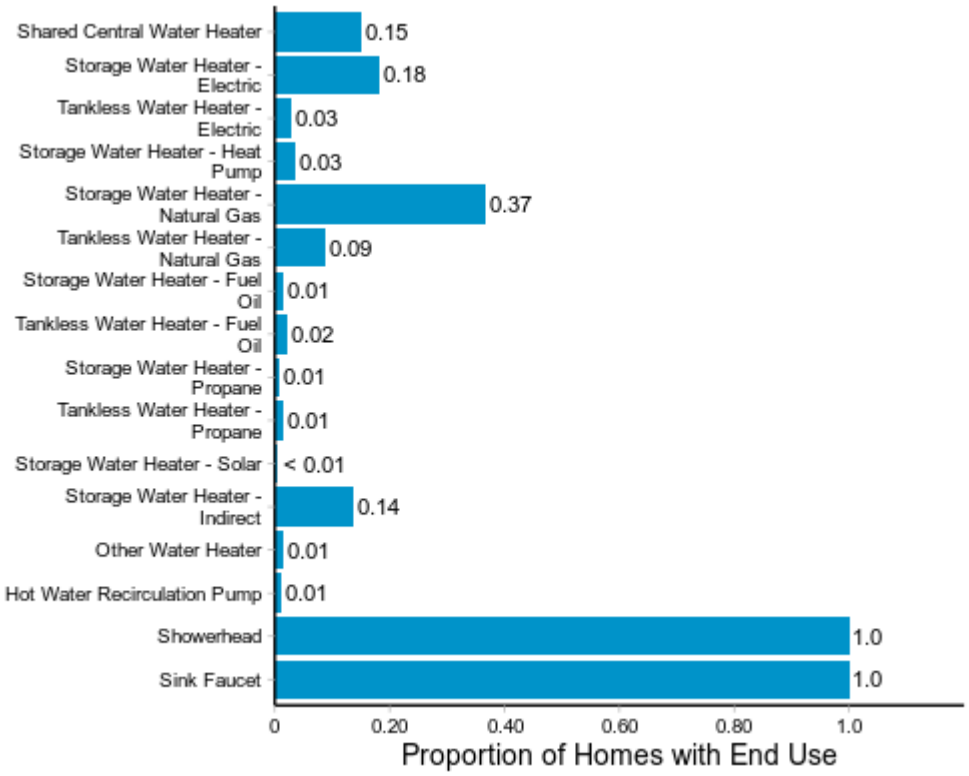


Source: Guidehouse analysis

3.4 Water Heating End Uses

Figure 3-41 shows the distribution of water heating equipment in Massachusetts homes. Storage water heaters fueled by natural gas (37%) and electric (18%) are most common, while heat pump and tankless systems remain rare (<10%).

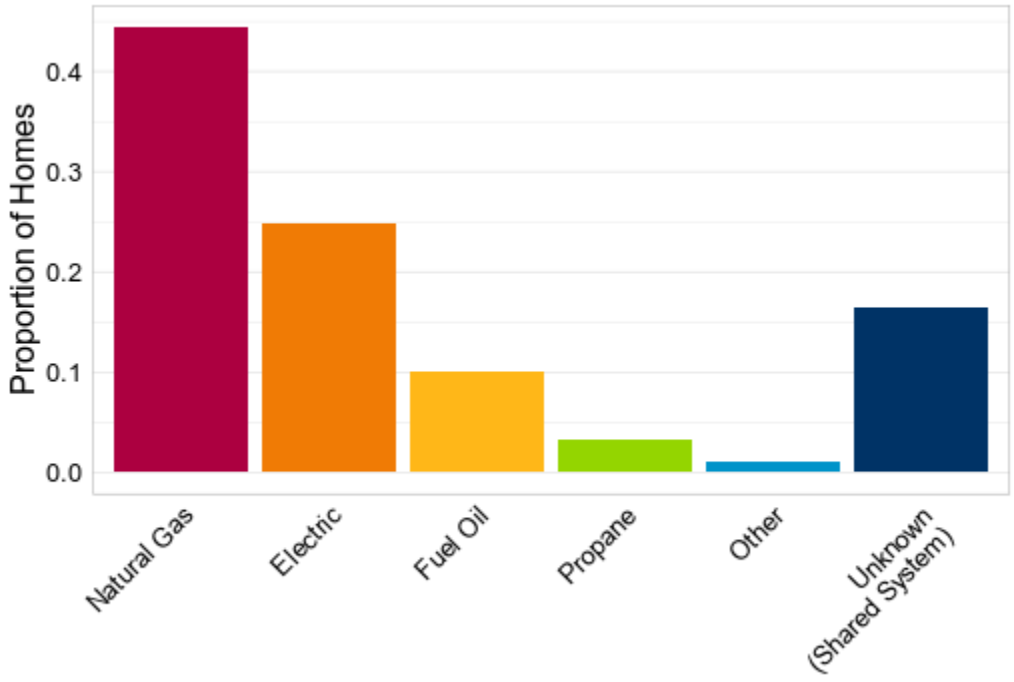
Figure 3-41. Water Heating End Use Saturation



Source: Guidehouse analysis

Figure 3-42 shows the proportion of homes by water heating fuel. Natural gas is the most common water heating fuel in Massachusetts homes, followed by electric and fuel oil systems. Fuel type information was not gathered for homes with shared water heating systems (for which the customer may not know the fuel type); these homes are marked as unknown.

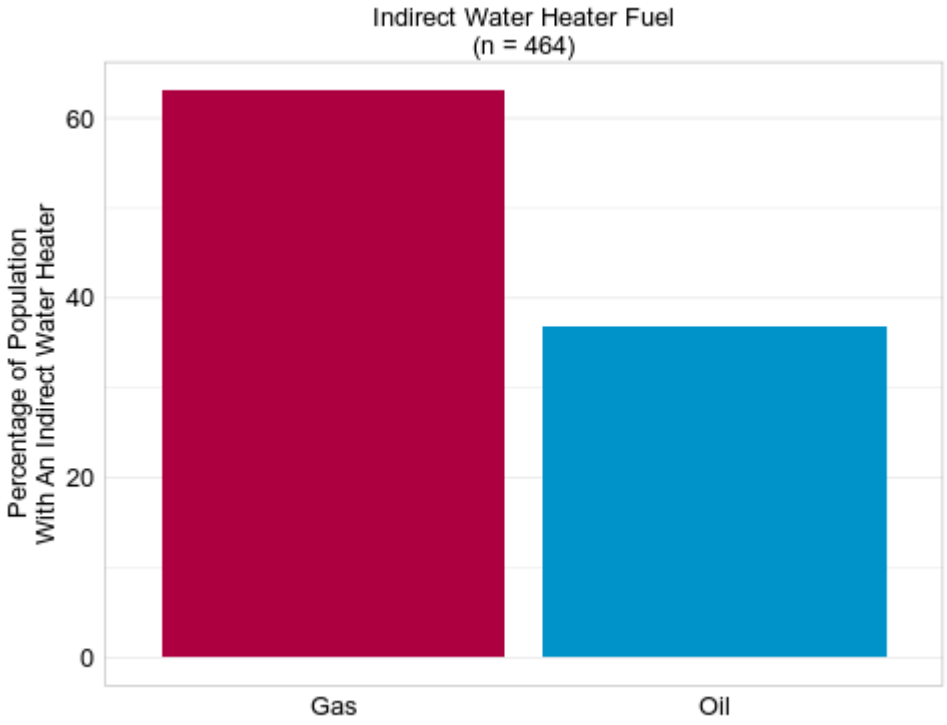
Figure 3-42. Water Heating Fuel



Source: Guidehouse analysis

Figure 3-43 shows the breakdown of indirect water heaters by boiler fuel type. Of all indirect water heaters, 63% are gas and 37% are oil.

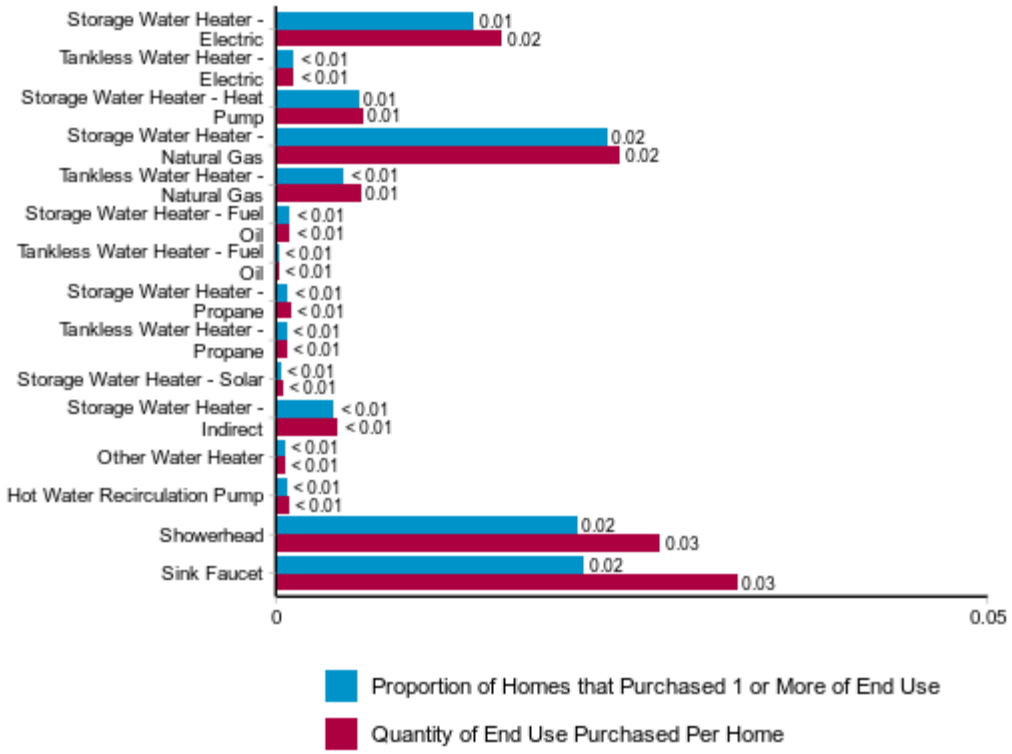
Figure 3-43. Indirect Water Heater Fuel



Source: Guidehouse analysis

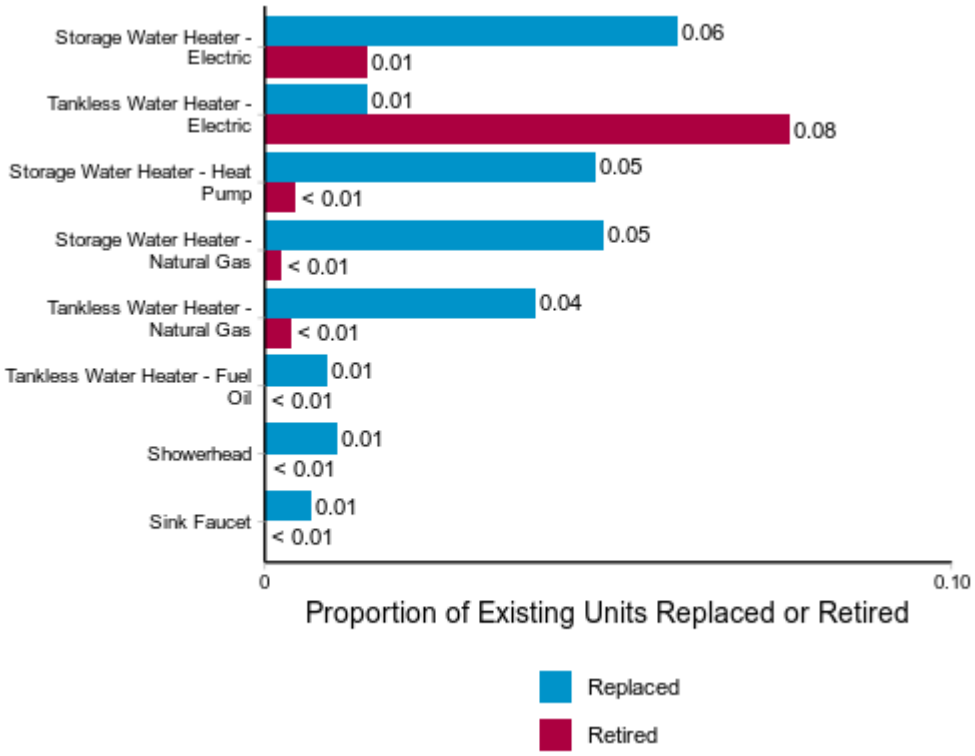
Figure 3-44 and Figure 3-45 show supporting information for the change in saturation. Figure 3-44 shows the proportion of homes that purchased new water heating equipment, either as an addition or a replacement. Figure 3-45 shows the proportion of existing water heater units replaced or retired in the past year. Traditional storage water heaters (electric and natural gas) dominate both purchases and replacements, while heat pump and tankless units show signs of growing adoption. Fixtures such as showerheads and faucets remain common purchase items, likely tied to efficiency upgrades. Very low retirement rates suggest market activity is driven by replacements and efficiency improvements, not by eliminating systems.

Figure 3-44. Proportion of Homes that Purchased New Water Heating-Related Equipment in the Past Year



Source: Guidehouse analysis

Figure 3-45. Proportion of Existing Water Heating-Related Equipment Replaced or Retired in the Past Year

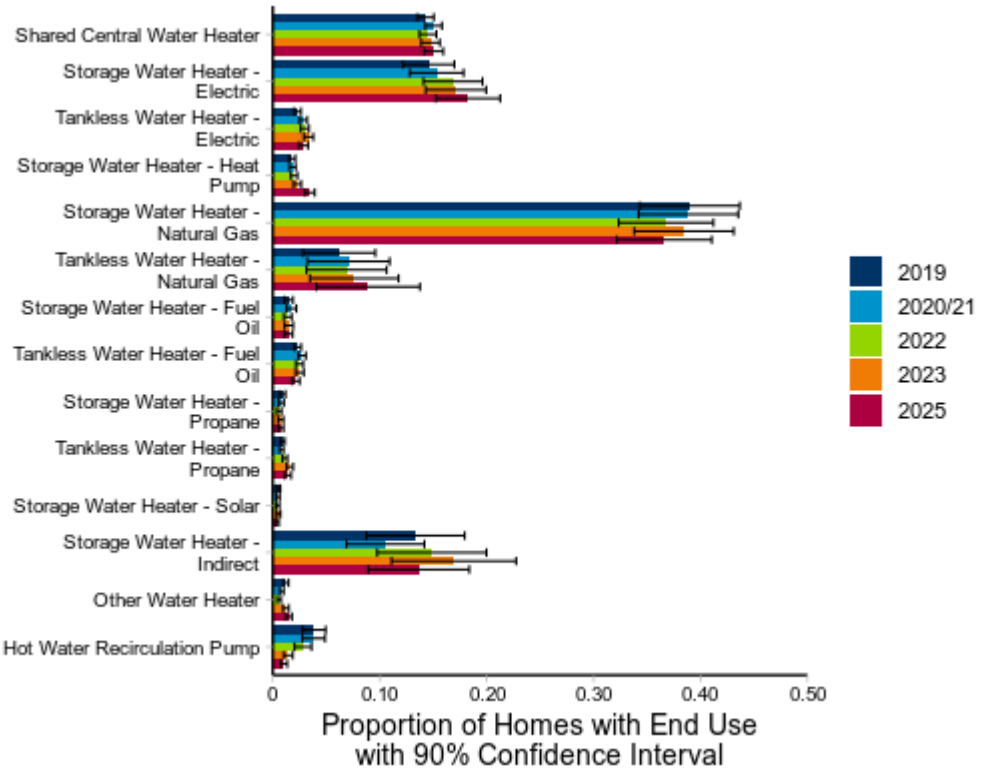


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-46 shows that conventional storage water heaters, particularly natural gas (~30%–35%) and electric (~15%–20%), remain dominant and largely stable from 2019–2025, while indirect and shared central systems each hold ~10%–15%. Heat pump water heaters (3%–5%) exhibit recent growth but remain niche. Tankless stays <10%, and solar/propane/fuel oil are <1%.

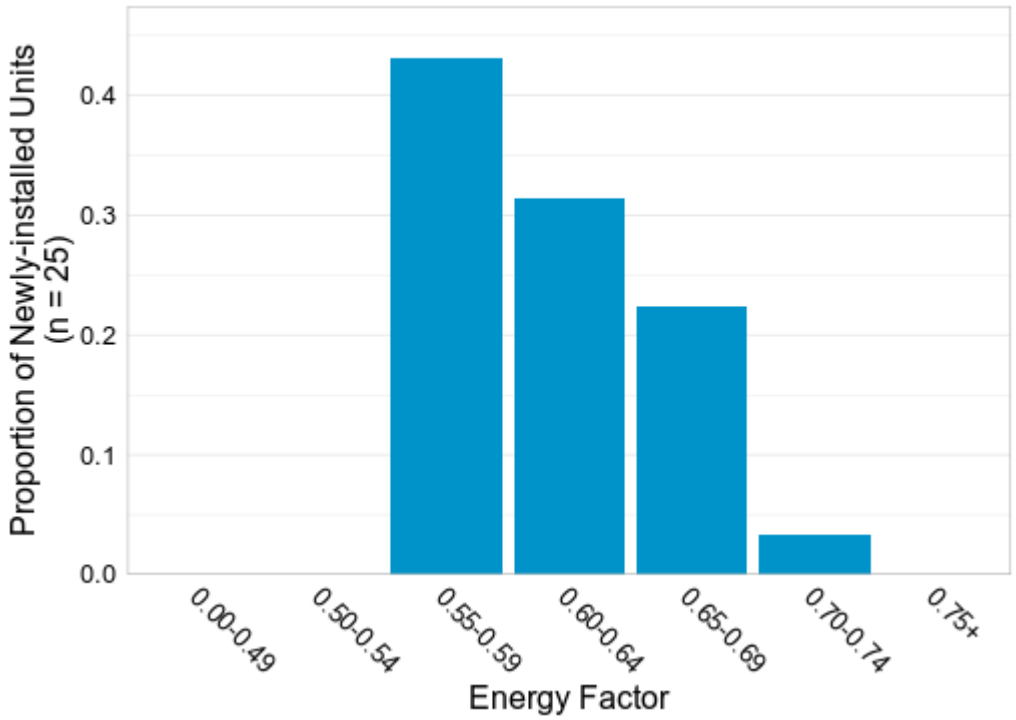
Figure 3-46. Water Heating End use Saturation Trends



Source: Guidehouse analysis

Figure 3-47 shows the distribution of energy factor (EF) values for newly installed gas tank water heaters.

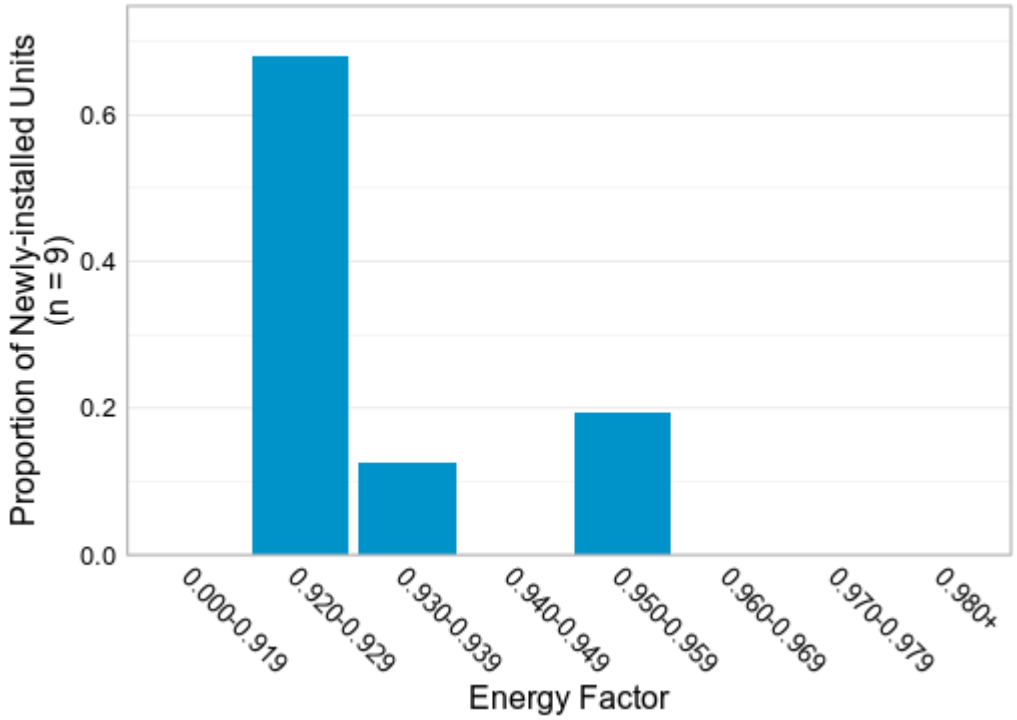
Figure 3-47. New Gas Storage Water Heater Efficiencies



Source: Guidehouse analysis

Figure 3-48 shows the distribution of EF values for newly installed electric resistance storage water heaters.

Figure 3-48. New Electric Resistance Storage Water Heater Efficiencies[16]

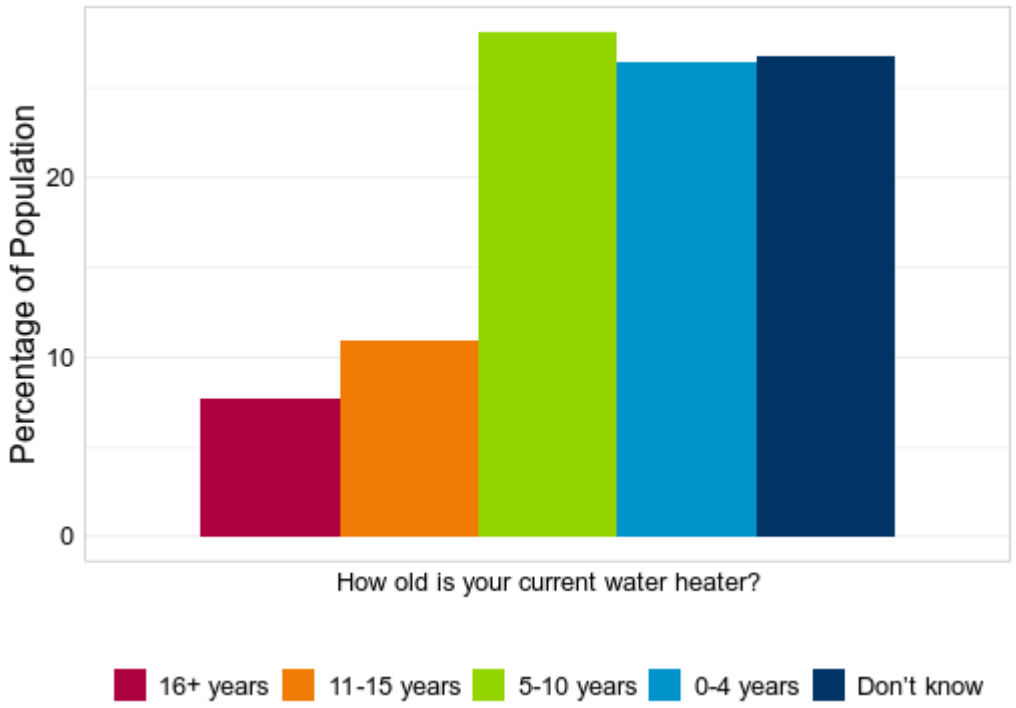


Source: Guidehouse analysis

[16] The sample size of new electric resistance storage water heaters in this phase was n = 9, so care should be used in interpreting the results.

Figure 3-49 shows the proportion of water heater ages. More than 55% of water heaters are less than 10 years old, but 8% of the population has units older than 16 years. About 27% of respondents noted they were unsure of their water heater's age.

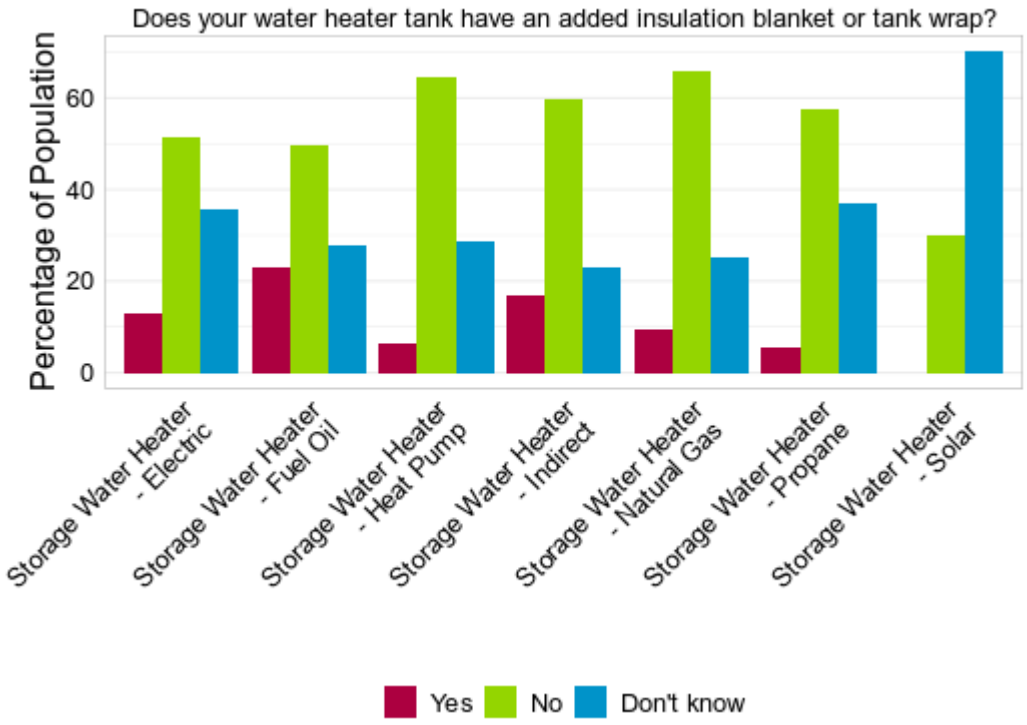
Figure 3-49. Age of Existing Water Heaters



Source: Guidehouse analysis

Figure 3-50 shows the proportion of water heaters that have an insulation blanket or tank wrap, by water heater type. Insulation is most common for indirect water heaters, though across all types, it is present for less than 25% of units.

Figure 3-50. Water Heaters with Insulation Blanket or Tank Wrap

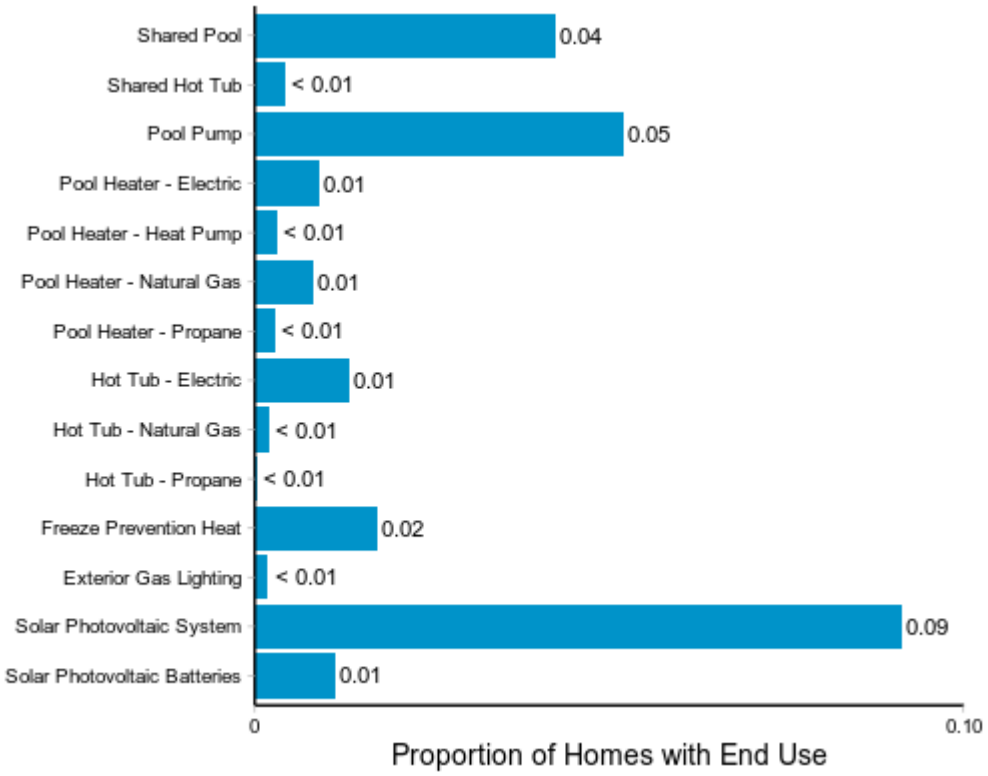


Source: Guidehouse analysis

3.5 Miscellaneous End Uses

Saturation of several miscellaneous end uses were included in the customer survey. For easy visualization, the miscellaneous end uses have been split into outdoor end uses, garage end uses, and electronic end uses. Figure 3-51 shows the saturation of miscellaneous outdoor end uses in Massachusetts homes.

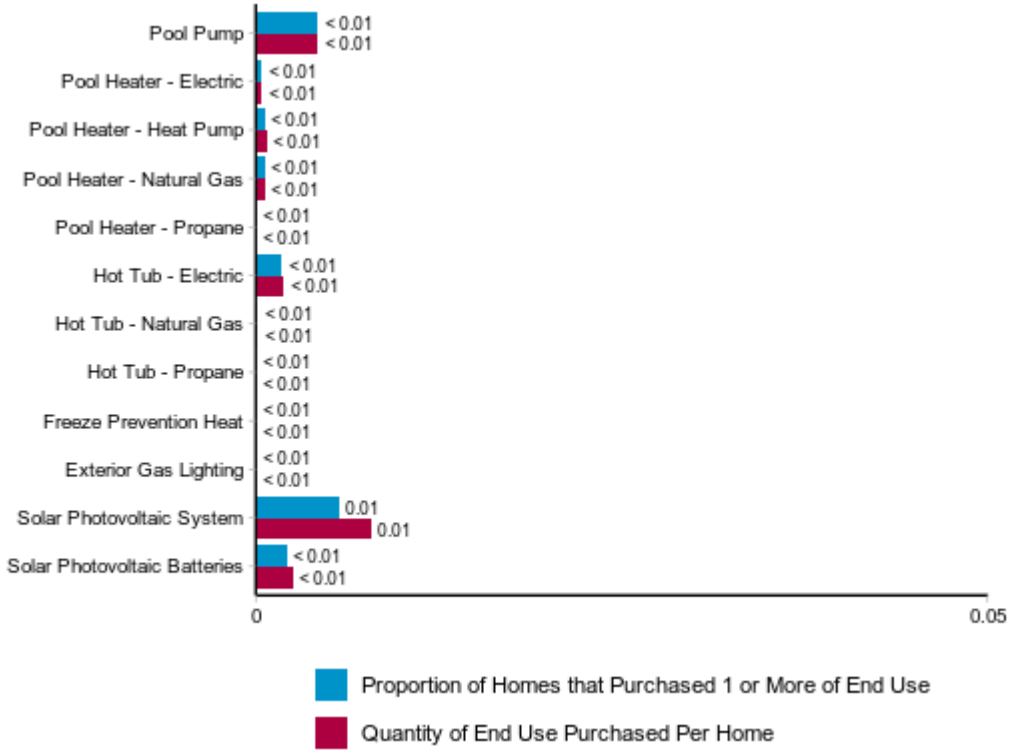
Figure 3-51. Miscellaneous End Use Saturation – Outdoor



Source: Guidehouse analysis

Figure 3-52 shows supporting information for the change in saturation by showing the proportion of homes that purchased new miscellaneous outdoor equipment.

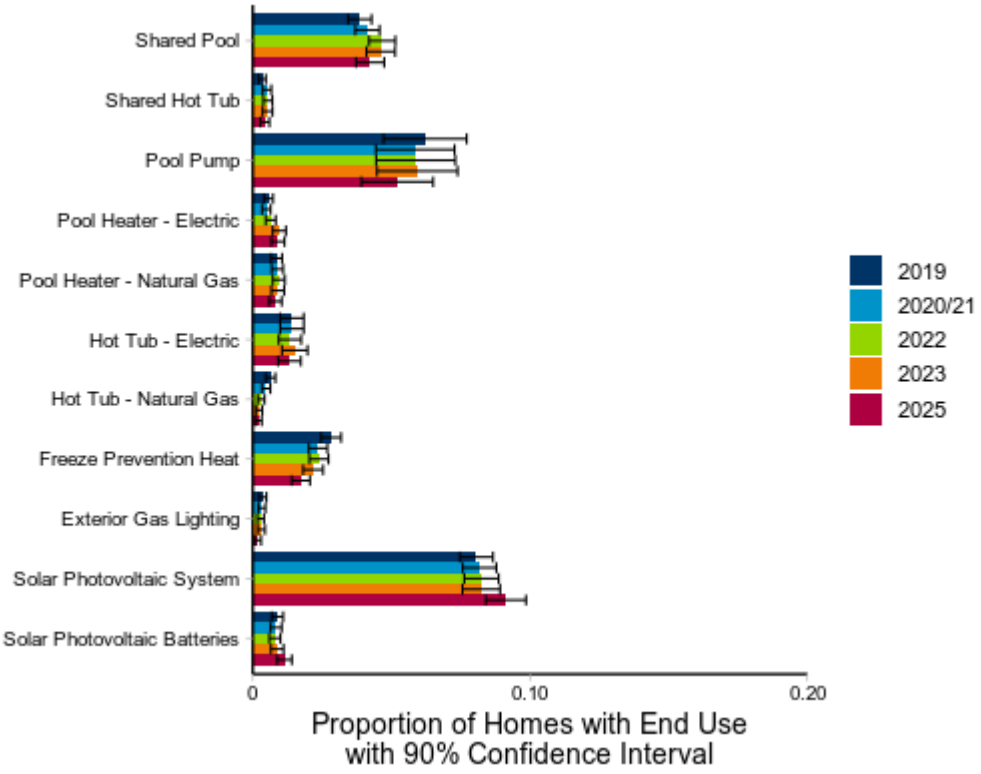
Figure 3-52. Proportion of Homes that Purchased New Miscellaneous Equipment –Outdoor



Source: Guidehouse analysis

Figure 3-53 shows the proportion of homes with various outdoor end uses from 2018 to 2025. Overall, outdoor equipment adoption is steady, with pool pumps and solar PV systems being the most prevalent home features.

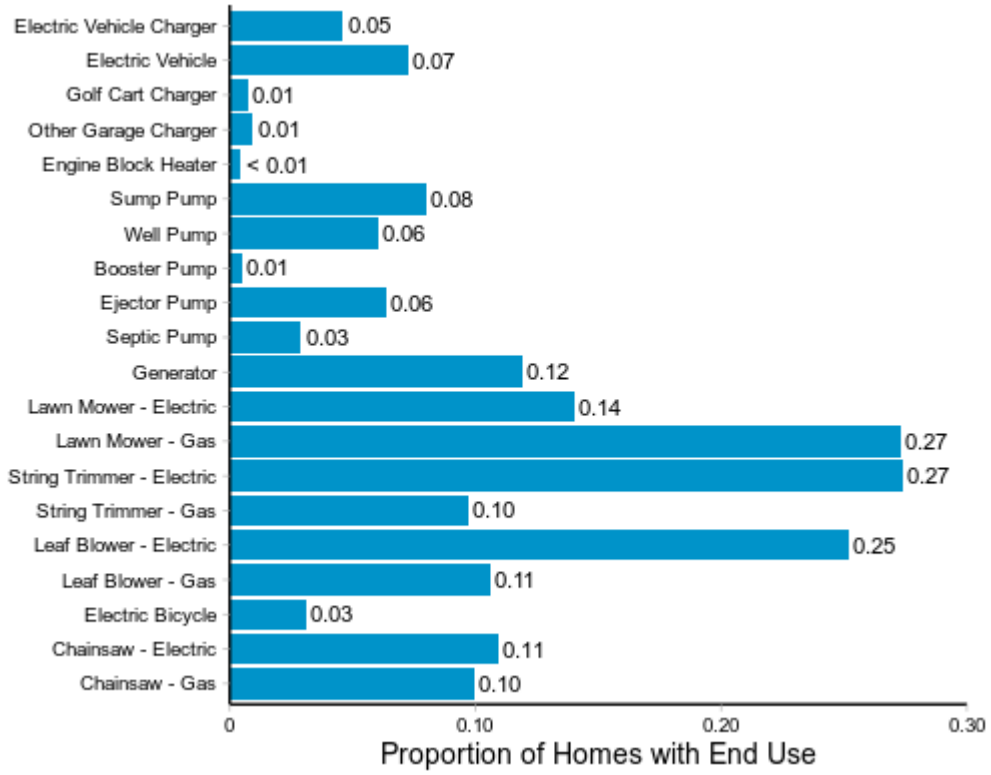
Figure 3-53. Miscellaneous Outdoor Saturation Trends



Source: Guidehouse analysis

Figure 3-54 shows the proportion of homes with various garage-related end uses. Overall, gas-powered outdoor tools remain the most prevalent garage end use, with electric alternatives and generators also widely adopted.

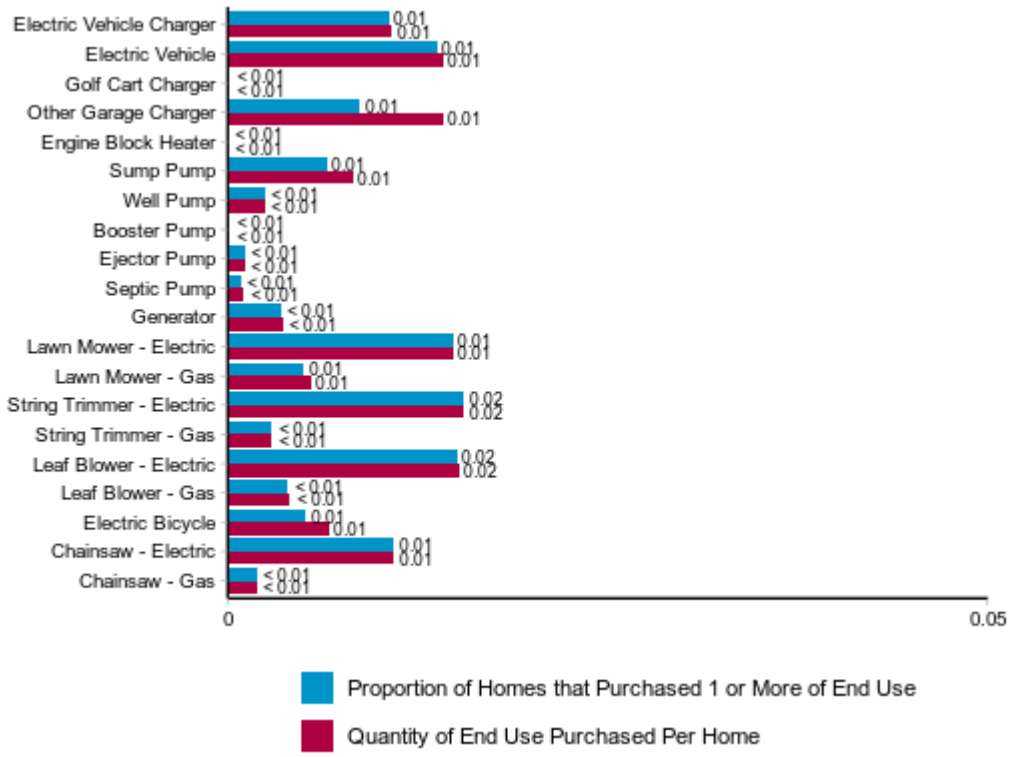
Figure 3-54. Miscellaneous End use Saturation – Garage



Source: Guidehouse analysis

Figure 3-55 shows the proportion of homes that purchased one or more garage-related end use and the average quantity of each end use purchased per home.

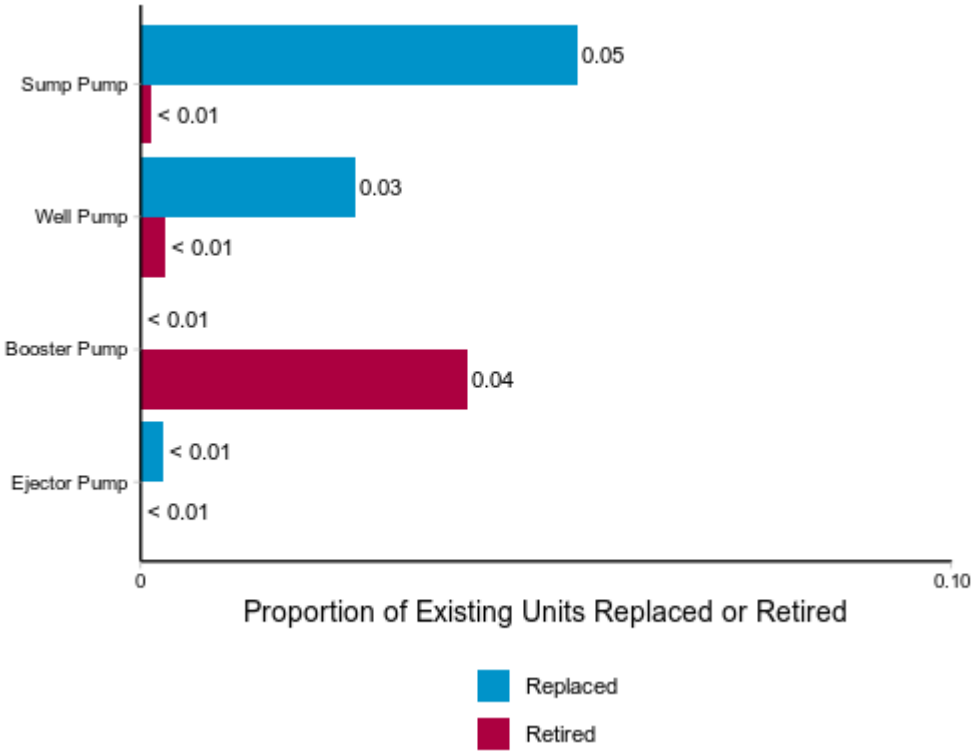
Figure 3-55. Proportion of Homes that Purchased New Miscellaneous Equipment – Garage



Source: Guidehouse analysis

Figure 3-56 shows the proportion of existing sump pumps, well pumps, booster pumps, and ejector pumps that were replaced (blue bars) or retired (maroon bars).

Figure 3-56. Proportion of Existing Miscellaneous Garage Units Replaced or Retired in the Past Year

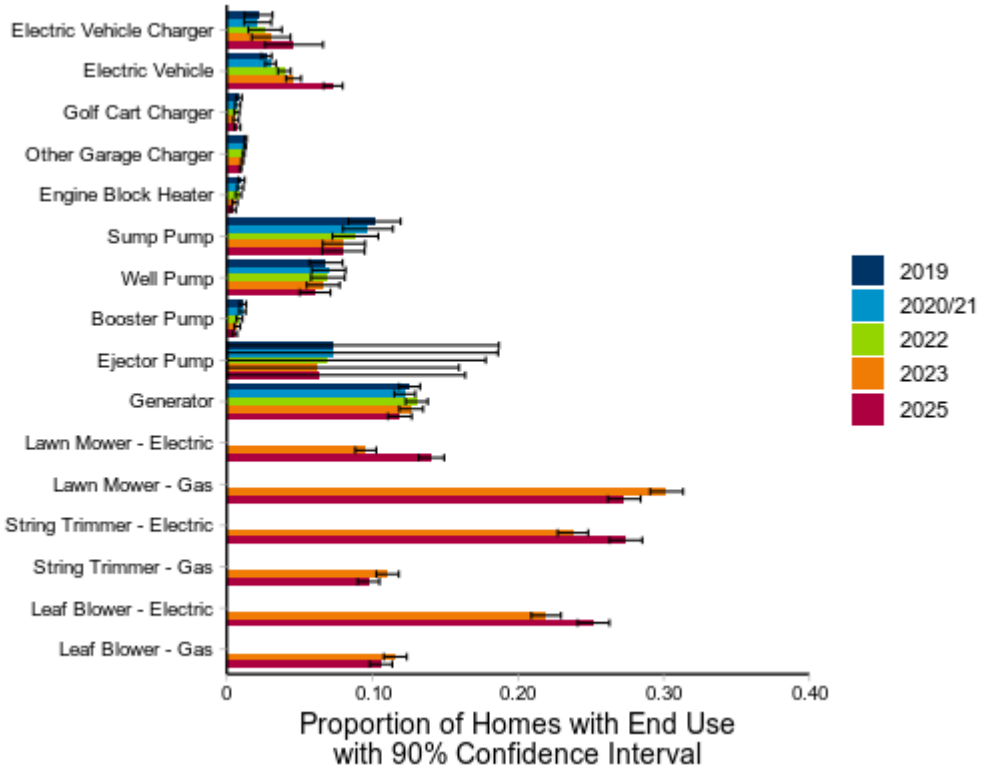


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-57 tracks the saturation of various garage-related end uses in homes over time. Gas-powered lawn mowers, string trimmers, and leaf blowers consistently have the highest saturation.

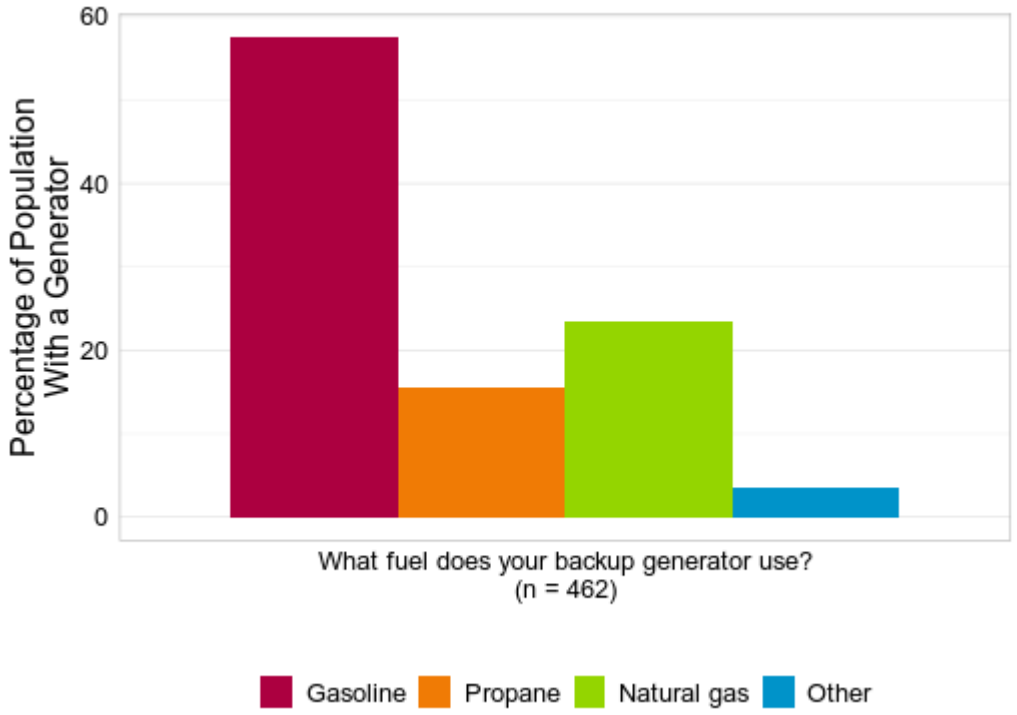
Figure 3-57. Miscellaneous Garage Saturation Trends



Source: Guidehouse analysis

Figure 3-58 shows that most backup generators use gasoline as their fuel source, indicating that gasoline remains the dominant fuel for backup generators, with natural gas and propane as notable alternatives.

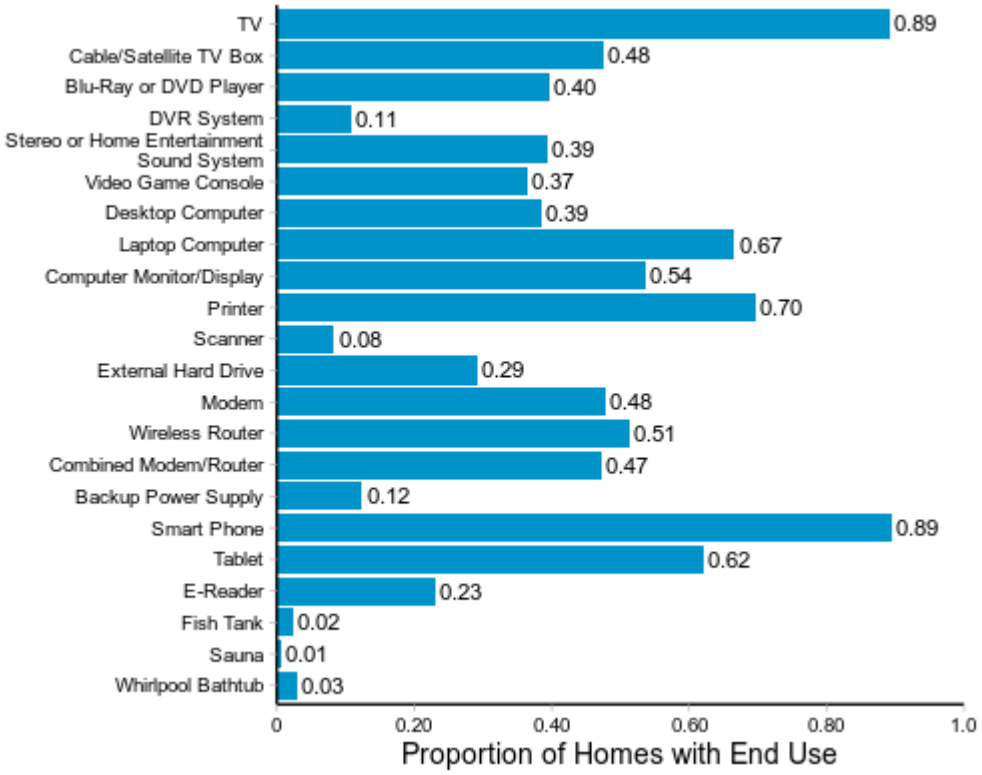
Figure 3-58. Fuel Type for Backup Generator



Source: Guidehouse analysis

Figure 3-59 shows the distribution of miscellaneous electronic end uses in Massachusetts homes. The plot highlights the prevalence of entertainment and computing devices in most households, with TVs and smartphones being nearly universal.

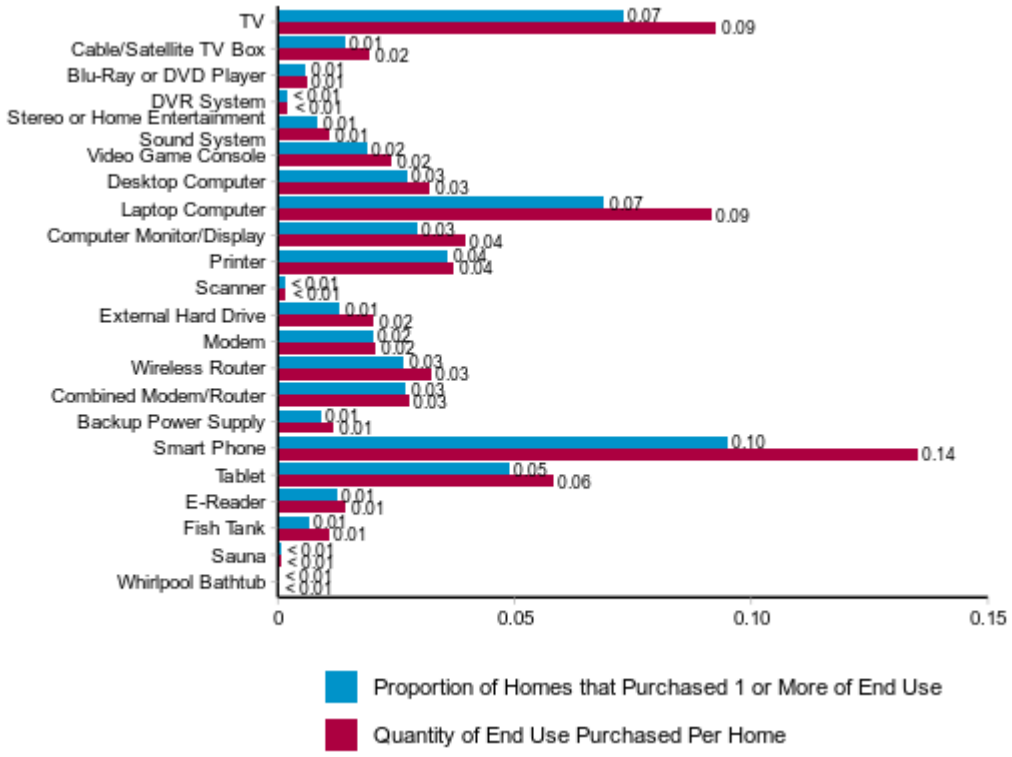
Figure 3-59. Miscellaneous End use Saturation – Electronics



Source: Guidehouse analysis

Figure 3-60 shows the proportion of homes that purchased new miscellaneous electronic equipment, displaying two metrics for each device: the proportion of homes that purchased at least one unit and the average quantity purchased per home. The data suggests that although certain electronics are widely adopted, new purchases are relatively rare and usually involve only one unit per home.

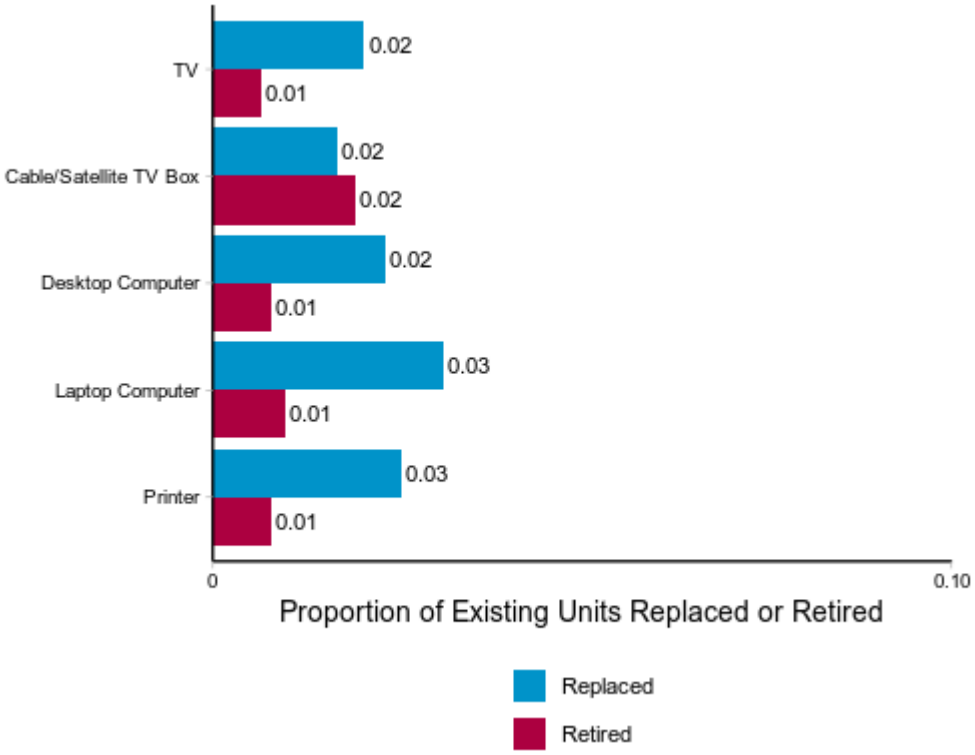
Figure 3-60. Proportion of Homes that Purchased Miscellaneous Equipment – Electronics



Source: Guidehouse analysis

Figure 3-61 shows the proportion of existing miscellaneous electronics units replaced or retired in the past year.

Figure 3-61. Proportion of Existing Miscellaneous Electronics Units Replaced or Retired in the Past Year

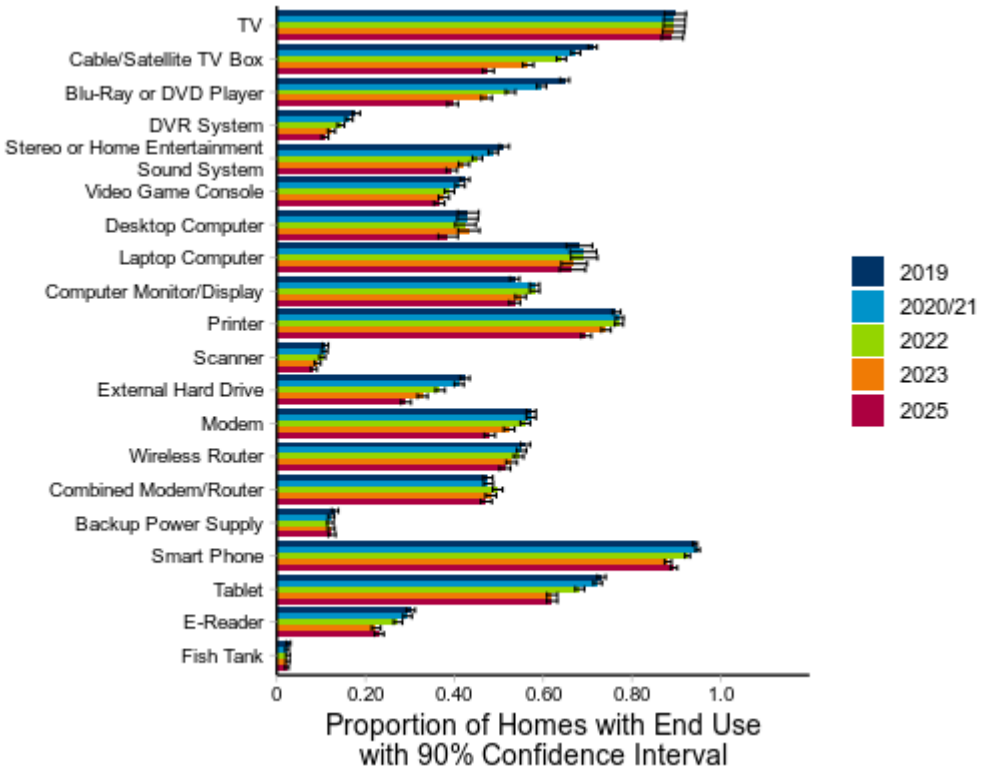


*Mortality rate (replaced + retired) is inversely proportional to EUL (e.g., EUL ~1/mortality rate).

Source: Guidehouse analysis

Figure 3-62 shows the trends in saturation between 2018 and 2025 for miscellaneous electronics end uses. Overall, the plot highlights the widespread and consistent presence of entertainment and computing devices in households, with little change in adoption patterns for most categories over the observed period.

Figure 3-62. Miscellaneous Electronics Saturation Trends[17]



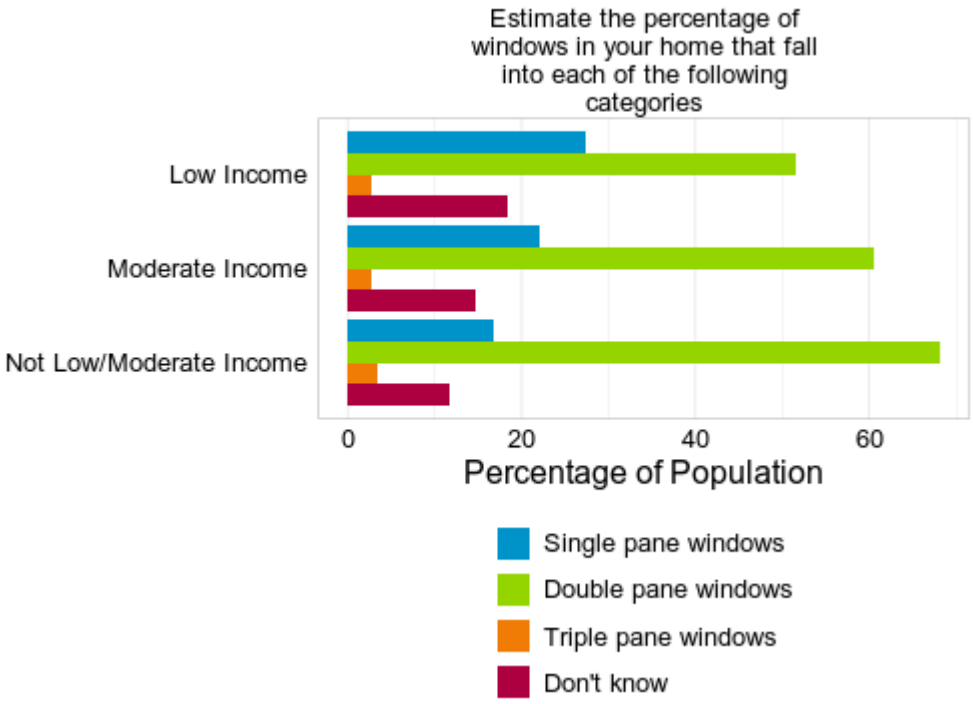
Source: Guidehouse analysis

[17] The decrease in stereo, tablet, and e-reader saturation might be in part due to respondents not entering complete data. See Appendix A for further details.

3.6 Building Characteristics

This section details miscellaneous building characteristics included in the survey. Figure 3-63 presents window results from the survey by income level.

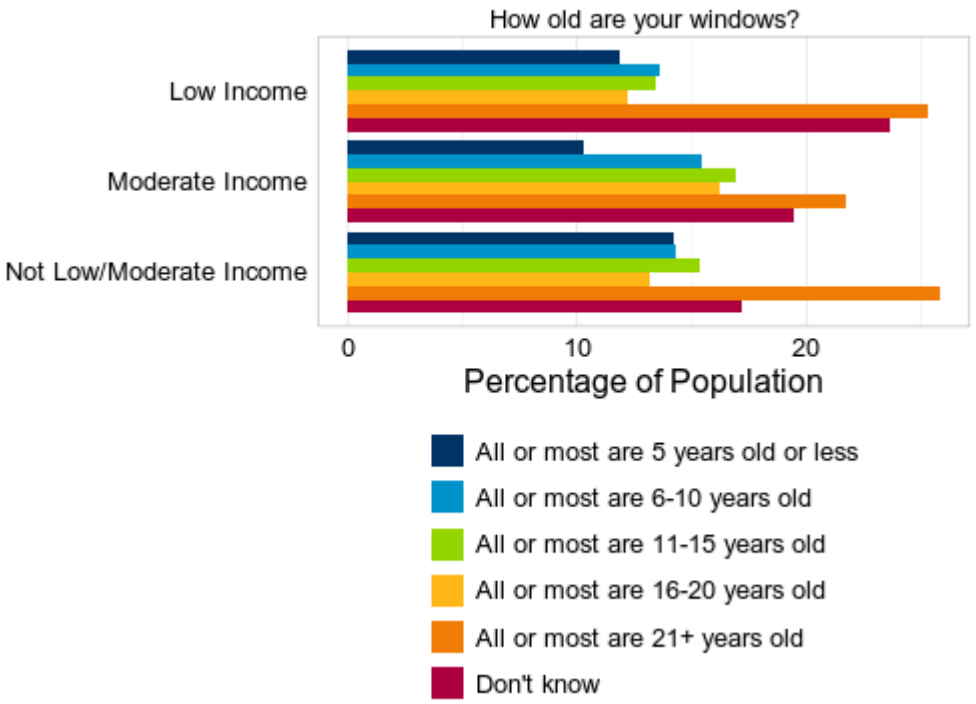
Figure 3-63. Window Type by Income Level



Source: Guidehouse analysis

Figure 3-64 shows comparable results between income levels for the age of windows.

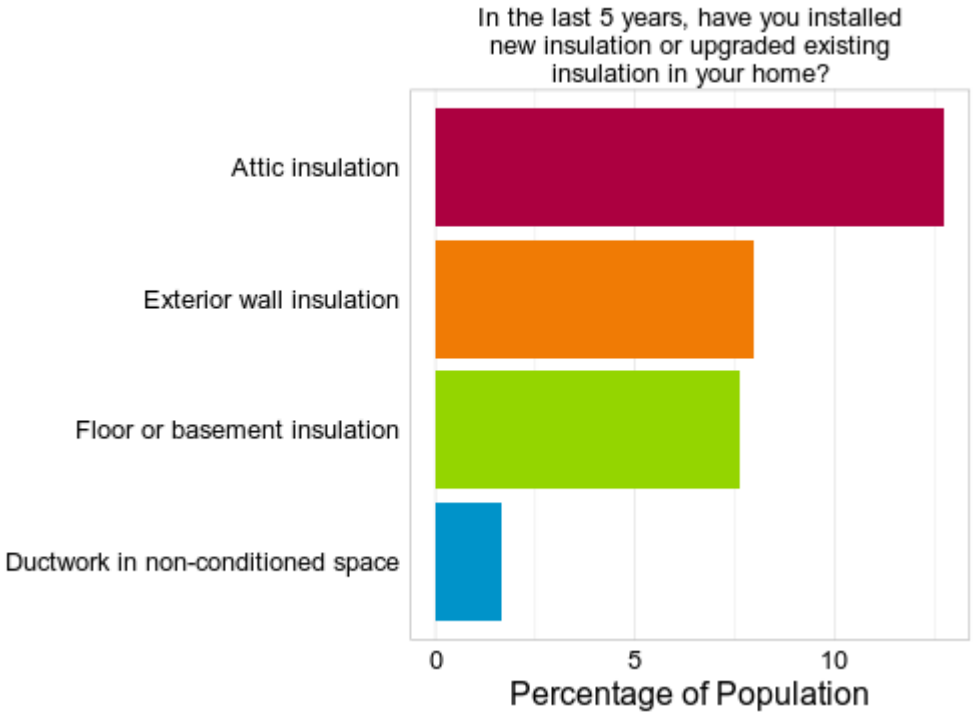
Figure 3-64. Window Age by Income Level



Source: Guidehouse analysis

Figure 3-65 shows the percentage of households that installed or upgraded insulation in the past 5 years. Attic insulation is the most common upgrade, followed by exterior wall insulation and floor/basement insulation.

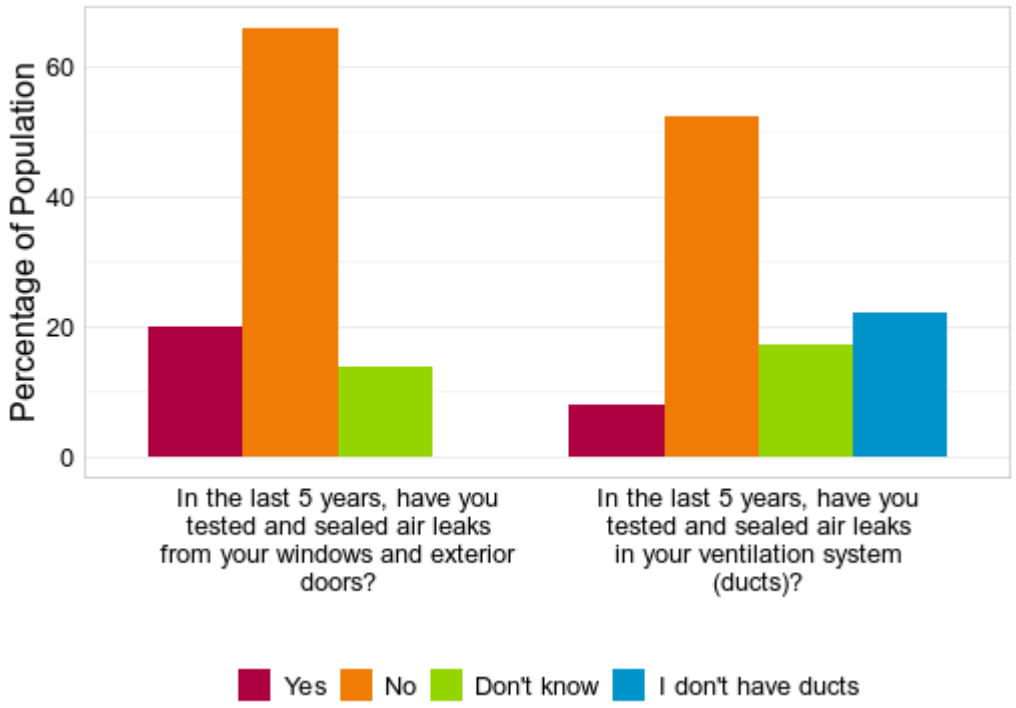
Figure 3-65. Percentage of Population Who Installed or Upgraded Insulation



Source: Guidehouse analysis

Figure 3-66 shows actions taken in the past 5 years to seal air leaks. Most households have not taken steps to seal air leaks, especially in ventilation systems, with a significant portion either unsure or lacking ducts altogether.

Figure 3-66. Percentage of Population Who Has Tested and Sealed Air Leaks



Source: Guidehouse analysis

3.7 TRM Inputs

Table 3-1 presents EUL values derived from the customer survey responses. EUL has been estimated as the inverse of the mortality rate of devices, which is defined as the proportion of units replaced or retired on an annual basis. The EUL estimates in this table are derived using an average of the proportion of units replaced or retired values derived from the surveys conducted over the past two phases.

These EUL estimates are not intended to replace the existing values in the Massachusetts TRM directly. Rather, they should be used as a comparison data source among other research to inform the EUL estimates. Due to the nature of the survey design in this study, the EUL estimates from this study might be overestimated in specific instances, as the survey does not capture the flow of units retired when customers move to a new address. However, these results also do not account for program-induced early retirements driving up mortality, which would cause an underestimate of EUL. Some end uses with rapidly changing saturation have been left out of the table, as these fast changes in saturation skew the simple mortality estimates. As detailed in 4.2Appendix A, the follow-up survey excludes customers who have moved in the past year and captures only the flow of equipment if the customer has remained at the same address.

Table 3-1. EUL by End Use

End Use	EUL
Furnace - Gas	19
Boiler - Gas	19
Boiler - Oil	35
Thermostat	20
Dehumidifier	21*
Humidifier	15*
Refrigerator	23
Domestic Hot Water - Electric	12
Domestic Hot Water - Gas	18
Clothes Washer	18
Clothes Dryer - Electric	20

*Saturation for this end use has increased or decreased year-over-year for the past 3 years, which may cause the EUL estimate to be inaccurate.

Source: Guidehouse

4. Overall Conclusions and Considerations

4.1 Conclusions

Efficient Technology Adoption

- Heat pump technologies (mini-split heat pumps, heat pump water heaters, heat pump dryers) are showing steady growth, indicating increased interest in electrification and energy efficiency.
- Saturation of Room/window air conditioners and central air conditioners is declining, which may be due in part to greater adoption of heat pumps.
- EV ownership is growing, with BEVs preferred over PHEVs, but home charging infrastructure varies.
- Induction cooktops and ranges have low adoption, suggesting an opportunity for increasing awareness of their efficiency benefits.

Water Heating

- Conventional storage water heaters (natural gas and electric) dominate, but heat pump water heaters are gaining ground.
- Most water heaters are less than 10 years old, though about a quarter of households don't know the age, highlighting the opportunity for incentivized early replacement.

Behavioral Change and Energy Burden

- Households with declining income are more likely to change energy consumption behavior, and energy burden remains high for low-income groups.
- Most customers have tried to save on energy bills, but adoption of advanced efficiency measures is limited.

Barriers to Heat Pump and Heat Pump Water Heater Adoption

- Awareness of heat pumps is moderate (60%) and knowledge of heat pump water heaters is lower (35%).
- Barriers to adoption of heat pumps and heat pump water heaters include upfront costs, lack of information, and concerns about performance and installation complexity.

Heat Pump Maintenance and Quality Assurance

- Over 20% of heat pump owners report maintenance issues, with refrigerant leaks being a common problem.
- Installation quality and post-installation support for heat pumps are critical for long-term performance and customer satisfaction.

Electrification Readiness and Panel Capacity

- Many homes lack sufficient electrical capacity (especially those with 100A panels) for full electrification (heat pumps, EV chargers, electric cooking).
- Smart panel adoption is very low (~10%) and many homes would require upgrades to support future electrification.

Insulation and Air Sealing

- Attic insulation is the most common upgrade, but overall insulation improvements remain low (<12% of households in 5 years).
- Air sealing is underutilized—only 20% of households sealed windows/doors, and just 8% sealed ducts, leaving energy savings untapped.

4.2 Considerations

Accelerate Electrification and High-Efficiency Adoption

- Consider expanding incentives for heat pump technologies (space heating, water heating, dryers) and induction cooking to help further offset upfront costs and make these technologies more affordable for households.
- Target homes with mid-aged equipment (5-10 years old) for early replacement campaigns, leveraging rebates and financing.
- Pilot programs for emerging technologies (e.g., induction cooking, smart panels, heat pump dryers) to accelerate market adoption.

Enhance Insulation and Air Sealing Programs

- Continue to promote attic, wall, and floor/basement insulation through outreach and financial support.
- Refine air sealing efforts by prioritizing measures with the highest energy savings potential.

Conduct Consumer Education, Outreach, and Quality Assurance

- Develop clear guidance on lifecycle costs and energy savings for efficient technologies.
- Provide educational materials on DIY air sealing, insulation upgrades, and the benefits of heat pump systems.
- Address knowledge gaps about heat pump water heaters and integrated controls.
- Strengthen contractor training and post-installation inspections of heat pumps to reduce maintenance issues.

- Monitor installation quality and provide feedback to improve long-term performance of heat pumps.

Support Panel and Load Management Upgrades

- Incentivize electrical panel upgrades and smart panels to enable full-home electrification and EV charging. Promote awareness of load management solutions and code changes (e.g., NEC Article 220.70) to facilitate electrification without costly service upgrades.
- Coordinate with utilities and municipalities to support home EV charger installations and grid readiness.

Provide Equity, Income, and Behavioral Support

- Focus programs on income-eligible households to help reduce energy burden.
- Ensure access to incentives and support for low- and moderate-income customers, especially for HVAC and water heating upgrades.
- Enhance behavioral programs and outreach, focusing on practical, low-cost actions for high-burden households.
- Increase visibility and accessibility of financial assistance programs, including Mass Save rebates and federal tax credits.

Table 4-1. Key Conclusions and Considerations

Area	Conclusion/Trend	Consideration
Replacement Activity	Upgrades > retirements, efficiency rising	Target mid-aged units for proactive replacement
Technology Adoption	Heat pump, EV, and induction adoption growing but barriers persist	Engage contractors, plan EV infrastructure planning, pilot emerging tech programs
Water Heating and HVAC	Storage heaters dominate, heat pumps rising	Promote heat pump water heaters, panel upgrades
Equity and Income	Low-income households face higher burden and rely on behavior changes	Prioritize support for low/moderate income households, ensure access to rebates and tax credits
Behavioral Change	High energy burden drives behavior change	Expand behavioral programs, increase visibility of financial assistance
Consumer Awareness	Moderate for heat pumps, low for heat pump water heaters	Increase education/outreach
Maintenance and Quality Assurance	Heat pump maintenance issues common	Strengthen contractor training, enhance post-installation support and quality assurance standards
Electrification Readiness	Many homes lack panel capacity, smart panel adoption very low	Subsidize upgrades, promote smart panels and load management solutions
Insulation and Air Sealing	Low adoption, attic most common	Expand Refine insulation/air sealing programs

Source: Guidehouse

Appendix A. Methods

A.1 Online Survey

The team built the Phase 8 survey on the previous year's instrument, with updates reviewed by EEAC consultants and PAs. The team incorporated feedback to improve clarity and relevance. They translated the survey into Spanish and Brazilian Portuguese, with native speakers verifying accuracy, and programmed and tested the instrument in Qualtrics in all three languages.

The team used both emails and postcards for survey recruitment. Two pilot email waves (500 customers each) preceded the full launch. The main follow-up survey went to 5,515 customers in March 2025, with up to two reminder emails and a postcard. The team distributed new customer surveys in six waves, using both email and postcards, adding reminders to boost response rates. Larger format postcards in Waves 4 and 5 included 10 languages from the Language Access Plan. The team also incorporated an additional email-only outreach attempt to boost response rates.

Both surveys closed on September 17, 2025. The follow-up survey achieved a 38% response rate (2,082 useable completes), and the new customer survey achieved a 1.2% response rate (2,749 usable completes), totaling 4,831 usable responses. Of these, 28 responses received were in Spanish and five in Brazilian Portuguese.

Over Phase 8, the team added and omitted questions to the follow-up and new customer surveys including the following changes:

- Omitted questions on occupant usage and behavior changes post-COVID-19, recruiting metering participants, and heating system effectiveness during the 2021-2022 winter
- Added questions about electrical panel schedules, smart panels, tax credits claimed, rebate/discount adoption factors, and heat pump installation dates

A.1.1 Follow-Up Survey

Guidehouse administered the follow-up survey to 5,515 Massachusetts residents who had previously completed the 2023 survey. To maximize engagement, each participant received an initial invitation via both email and postcard. For those who did not respond, up to three reminder emails and an additional reminder postcard were sent. All communications included a direct link to the online survey and highlighted the incentive of a $25 Tango e-gift card[18] for completion. Prior to full deployment, the survey underwent pilot testing and rigorous quality assurance to ensure a smooth respondent experience.

The primary objective of the follow-up survey was to update the saturation data for key residential end uses collected in the prior year. Respondents were asked to report the number of units currently installed, the number added, and the number removed in the past year for each major equipment category. For example, participants indicated how many thermostats were currently in

[18] Tango e-gift card refers to the Rewards Genius and Tango Card platform. This platform allows customers to redeem their incentive from a variety of retailers (such as Amazon), as a Visa card, or for charitable donation.

their home, how many were installed in the past year, and how many were removed. To reduce respondent burden, the survey allowed participants to skip questions for end uses that were not applicable.

End uses were organized into the following categories:

- Heating and cooling equipment
- Kitchen appliances
- DHW systems
- Laundry equipment
- Outdoor and garage equipment
- TV and computer equipment
- Wi-Fi-enabled devices
- Miscellaneous equipment

The secondary objective was to collect detailed characterization data for high-priority end uses. If a respondent reported installing one of these end uses, they were prompted to provide manufacturer and model information, either by uploading a photo of the equipment's nameplate or by manually entering the details. Completion of this characterization module qualified the respondent for an additional $25 Tango e-gift card. This approach enabled the collection of granular data on new equipment installations, including size and efficiency, supporting more accurate program planning and evaluation.

Table A-1 summarizes the recruitment and response rates for the follow-up survey. To be eligible for the characterization module, respondents needed to have installed one of 42 high-priority end uses in the past year. Only those who agreed to provide nameplate information—either via photo or manual entry—were counted as completes for the characterization portion. Residents who indicated they no longer lived at the address on file were excluded from the completion rate calculations.

In total, 38% of residents completed the saturation portion of the follow-up survey, and 43% of those eligible completed the characterization module. This robust response supports the reliability and representativeness of the study's findings.

Table A-1. Follow-Up Survey Recruitment Summary

Wave	Number Contacted	Initial Postcards Sent	Emails Sent	Saturation Survey Attempts		Saturation Survey Completes		Eligible for Characterization Survey		Characterization Survey Completes	
				n	%	n	%	n	%	n	%
Total	5,515	5,515	3,218	2,687	48.7%	2,082	37.8%	808	38.8%	347	42.9%

Source: Guidehouse analysis

A.1.2 New Customer Survey

To expand the reach and representativeness of the study, Guidehouse distributed the online survey to 225,000 Massachusetts residents using a combination of email and postcard invitations. Postcards were mailed to utility account addresses, inviting recipients to participate in the online survey and offering a $25 Tango e-gift card as an incentive for completion. Residents with an email address on file also received electronic invitations. To further encourage participation, reminder postcards and emails were sent to non-respondents throughout the recruitment period.

Survey Content and Structure

The new customer survey was designed to capture a comprehensive profile of Massachusetts households and their energy-related equipment. Key topics included:

- **Premises occupant demographics:** Number of occupants, age, work status, income, and homeowner versus renter status
- **Building characteristics:** Building type (single-family or multifamily), age, window type, time since last significant renovation, and recent upgrades
- **Major end uses and appliances:** Presence and type of equipment such as heating and cooling systems, kitchen appliances, water heaters, laundry equipment, and more
- **Detailed building and appliance characteristics:** For a subset of homes, additional questions addressed equipment usage, installation details, and efficiency features
- **Thermostat saturation and usage:** Information on the number and type of thermostats installed and their usage patterns

During Phase 8, Guidehouse worked with the data management team to obtain an updated active customer list (ACL), including program participation flags to denote customers that participated in a Mass Save program from 2018 to 2022. This dataset supported the development of a robust sample of approximately 225,000 customers. Sampling began with a list of previous phase survey respondents (5,515 customers). After launching the follow-up survey to existing customers and analyzing respondent demographics, targeted sampling was initiated to improve representation among key groups.

The team carried out the sampling process through the following steps:

1. **Sample Size Determination:** The team confirmed the desired total sample size in collaboration with project stakeholders.
2. **Statewide Distribution:** The team allocated approximately 55% of the sample was allocated across all Public Use Microdata Areas (PUMAs), weighted by population, to ensure statewide coverage and avoid over-concentration in specific regions. The team adjusted this distribution based on feedback from PAs and the project team.

3. **Demographic Targeting:** The team directed the remaining 45% of the sample towards the top 10-20 PUMAs or EJCs, selected and weighted using demographic data from the American Community Survey (ACS). The team compared survey respondent demographics with statewide ACS data to guide this weighting.

4. **EJCs:** The team further weighted census tracts to reflect the proportion of EJCs. This step, newly introduced in Phase 8, aimed to increase participation from non-English speakers, minority groups, and low-income households. The team also targeted EJCs during the regional distribution step to ensure comprehensive coverage.

5. **Multifamily Units:** Starting with the fourth wave of the new customer survey, the team ensured at least 25% of the sample consisted of potential multifamily addresses. This step, introduced in Phase 8, helped reach more renters statewide. The team identified multifamily buildings in the ACL using results from a previous study conducted with the PAs.[19]

6. **Utility Participation and Email Presence:** The team drew samples from pools identified by utility program participation and email availability in the ACL. Their goal was to match respondent utility participation and email presence to the ACL while accounting for response rates from previous waves.

Targeting Data Sources

- ACS Public Use Microdata Sample (PUMS) for population density
- ACS demographic data (race, renters, building type, primary language, income, education, age, household size, urban/suburban/rural status)
- Mass.gov data for EJCs
- ACL records for utility program participation and email presence

Table A-2. Sample Size

Phase - Period	Existing Sample Size	New Sample Waves	Total New Sample Size
6 - Spring 2022	6,316	3	62,000
7 - Spring 2023	4,369	5	110,130
8 - Spring 2025	5,515	11	225,000

Source: Guidehouse analysis

[19] Guidehouse, Massachusetts Census of Multifamily Buildings Study, December 21, 2022, MA21R34-B-MFCEN_Full_Report.pdf

Table A-3. Targeting Categories for Sampling Waves

Category	Pilot	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7	Wave 8	Wave 9	Wave 10	Wave 11
Total	5,000	35,000	35,000	25,000	25,000	25,000	25,000	10,000	10,000	5,000	5,000	20,000
Regular Spread	5,000	35,000	35,000	15,000	15,000	2,500	2,500	1,000	1,000	500	500	10,000
PUMA Targeted	-	-	-	10000	10,000	5,000	5,000	2,000	2,000	1,000	1,000	3,000
EJC Non-English	-	-	-	-	-	7,500	7,500	3,000	3,000	1,500	1,500	3,000
EJC Low Income	-	-	-	-	-	5,000	5,000	2,000	2,000	1,000	1,000	2,000
EJC Minority	-	-	-	-	-	5,000	5,000	2,000	2,000	1,000	1,000	2,000
MF Census Baseline % Tgt	-	-	-	-	50%	25%	25%	25%	25%	25%	25%	25%
MF Census Units	939	6,178	6,255	6,079	12,503	8,031	7,946	3,121	2,962	1,483	1,452	5,391
Outreach Type	Email Only	Email + Postcards	Email + Postcards	Email + Postcards	Email + Postcards	Email + Postcards	Email + Postcards	Email Only	Email Only	Email Only	Email Only	Email Only

*Note that the targeting rows EJC Non-English through MF Census Baseline % Tgt are the initial targeting splits that were applied. The regular spread and PUMA targeted spread portions will place more customers into these categories, as shown by the MF Census Units, which is the actual number of identified MF units and always exceeds the targeted percentage of the sample.

Source: Guidehouse analysis

The team thoroughly tested the final survey before implementing a pilot to 5,000 residents, followed by eleven recruitment waves.

Table A-4 summarizes the survey recruitment effort and the response rate. In total, 1.2% of residents completed the saturation portion of the new customer survey, and 36% of residents eligible to take the characterization survey completed it. The characterization survey requirements for new survey respondents matched that for the follow-up survey (described in Appendix A.1.1). Residents who indicated they did not live at the address on file were screened out of the survey and are not included in the completion rate counts in Table A-4.

Table A-4. Survey Recruitment Summary

Wave	Number Contacted	Postcards Sent	Emails Sent	Saturation Survey Attempts		Saturation Survey Completes		Eligible for Characterization Survey		Characterization Survey Completes	
				n	%	n	%	n	%	n	%
Pilot	5,000	5,000	5,000	186	3.7%	103	2.1%	37	35.9%	10	27.0%
Wave 1	35,000	35,000	13,683	955	2.7%	575	1.6%	189	32.9%	59	31.2%
Wave 2	35,000	35,000	13,315	984	2.8%	575	1.6%	182	31.7%	58	31.9%
Wave 3	25,000	25,000	9,567	677	2.7%	398	1.6%	139	34.9%	48	34.5%
Wave 4	25,000	25,000	16,088	446	1.8%	218	0.9%	72	33.0%	23	31.9%
Wave 5	25,000	25,000	17,541	483	1.9%	214	0.9%	93	43.5%	43	46.2%
Wave 6	25,000	25,000	16,338	586	2.3%	294	1.2%	104	35.4%	44	42.3%
Waves 7-11	50,000	0	50,000	786	1.6%	372	0.7%	129	34.7%	51	39.5%
Total	**225000**	**175000**	**141532**	**5103**	**2.3%**	**2749**	**1.2%**	**945**	**34.4%**	**336**	**35.6%**

Source: Guidehouse analysis

A.2 Data Analysis

The saturation data analysis followed the steps listed in Appendix A.2.1, while the electrification readiness analysis methodology is detailed in Appendix A.2.2.

A.2.1 Saturation Data Analysis

To derive updated saturation results, Guidehouse cleaned and summarized data from the latest phase of the online saturation and characterization survey, as outlined in Appendix A.1. A mix of new customers and customers who completed the online survey in the previous phase were sent the survey asking about current saturation and what had changed in the past year. The team combined the results from the original survey with the results from the new survey to generate saturation for all equipment types in residential homes in Massachusetts. Saturation was adjusted based on onsite verification and post-weighted based on the demographics of the survey respondents and the state of Massachusetts.

Step 1. Clean data: The following cleaning steps were taken:

- To address values that appeared to be mistakes in the survey responses, for quantities greater than 10 for most end uses or greater than 20 for sink faucets, showers, and gas lighting, the team changed values to 1.
- For heating systems, boilers and furnaces were switched based on the distribution type that was indicated. Where radiators were stated, the heating system was changed to boiler and where ducts were indicated, the system was changed to furnace.
- For ductless/central air conditioners, where responses indicated the unit could also provide heat, air conditioner was changed to heat pump.

Responses were dropped for customers that did not meet a set of criteria for having end uses that could reasonably be expected to be present in every home (customers that did not indicate having a refrigerator or that did not indicate a heating system of any kind).

Step 2. Adjust raw survey data using onsite findings: The team used onsite data from Phase 7 to adjust saturation using the ratio of the number of each type of equipment verified onsite to the number of each type of equipment claimed in the survey for each of the 300 sites visited for metering. Onsite adjustment factors were used for all end uses present in at least 10 sites. The Phase 7 update was the first update to the onsite adjustment factors since Phase 2. The update was possible because the survey now asks every customer (not just new customers) for full saturation information, where in past phases, it gathered information only on changes in saturation for existing customers. The update resulted in significant changes for a few end uses; the updated numbers are more accurate. The updated adjustments have been applied to all past years' data in the trend plots for consistency.

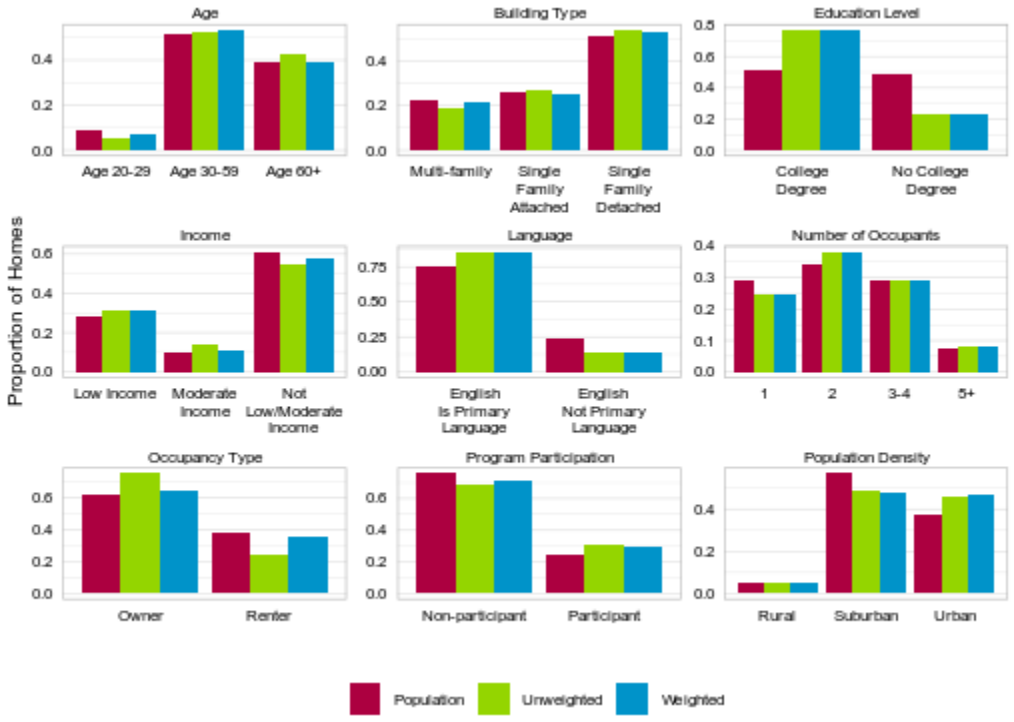
Step 3. Adjust original survey data using the results of the follow-up survey: The data for all customers from the previous phase was adjusted by the results of the current survey, in which each customer was asked the current quantity of each end use, as well as the quantity added and removed in the past year. In cases where the customer indicated that the quantity had been

changed, the previous quantity was updated to the current survey quantity accordingly, while in cases where no change was indicated, the previous quantity was used.

Step 4. Apply post-weights: In conjunction with the survey responses, the team developed a set of weights using demographics information from ACS. The demographics selected for weighting results were building type, occupancy type (renter versus owner), and income level. The team selected these demographics because they were the ones where the survey sample and Massachusetts population differed the most (considering both current and past years), and the ones most likely correlated with the end uses present in the home. The same post-weighting variables were used to derive new weights for past years' saturation data for the trend plots for consistency. Figure A-1 shows a comparison of the unweighted and weighted survey demographics to the Massachusetts statewide population.

Step 5. Calculate saturation: For each combination of the demographic slicing variables and for each individual slicing variable, separate saturation and quantities were computed for the entire Massachusetts population of that demographic. Post-weights were normalized for each combination of slicing variables to sum to 1. The weighted proportion of homes with the end use and weighted mean quantity per home were then calculated for each end use. The team also computed absolute precision at the 90% confidence level.

Figure A-1. Population vs. Survey Demographics[20]



Source: Guidehouse analysis

The saturation data from 2017 and 2018 has not been included in the saturation trends plots in this report due to differences in the survey instrument used in 2017 and in how income data was collected in 2017/2018 compared with the other survey years. These differences make comparisons with future years misleading.

A.2.2 Electrification Readiness

Homes' electrical service capacity is rated by the number of amperes (amps) of current that they can carry at peak load. This capacity depends on the age of the home (where most older homes had relatively smaller services), the decision of the builder, and where the home's electrical service has been retrofit.

Electrical capacity in homes has grown with the addition of loads such as air conditioners and as appliances and other uses of electricity has grown. Service panels as late as the early 1960s held fuses and had capacities of 60A. Homes built in the 1970s and later had service panels with circuit breakers and commonly had capacities of 100A. In the 1990s and later, 200A service panels

[20] The weighted values do not exactly match the population values for the chosen post-weighting variables due to a small number of missing values in the ACS data for some of those variables, which result in the three-dimensional proportions used in the post-weights being slightly different from the one-dimensional proportions (shown in the plot).

became more common. Today, most homes are built with 200A panels, and some have services as large as 400A.

Determining the remaining capacity of a panel is a bit more complicated than adding up the capacity of the breakers in the panel for three reasons:

1. A home would likely never have all of its loads on at once.
2. Breakers are sized to protect the wire serving an appliance and that wiring is sized to be at least 25% higher than the highest expected continuous load. Therefore, a 50A breaker serving an electric cooking range would never see a load greater than 40A, and where one or two burners are used, the load might typically be 15A or 30A.
3. The smallest breaker size is typically 15A, and these breakers can serve strings of outlets that are seldom used, and the breaker might only be loaded at 1A or 2A at maximum.

The NEC addresses the first two reasons listed above by counting the first 33A at 100% and remaining loads at 40%. The NEC addresses the third reason by assigning 0.0125A per square foot for miscellaneous lighting and receptacle loads.

To determine available capacity, this study first collected photographs of electrical panels through residential customer surveys to identify panel breakers and major appliances and their associated loads (see Figure A-2). Existing loads associated with electrification, such as electric heating, cooking, and EV chargers, were also cataloged. The next step was to perform calculations to estimate whether the current electrical service was sufficient for electrification or whether it needed to be upgraded. The team used the 2023 edition of the NEC recently adopted by Massachusetts.

Figure A-2 shows the main breaker size, the sizes of one and two-pole breakers, and labeling of the circuits. In many cases, there was no labeling, and the sizes of the breakers and knowledge of the home's loads were used to match breakers to loads.

The team used the portion of the code (Section 220.83) that applies to existing homes to calculate available capacity for new loads. Where the nature of a breaker's load was not fully known, the load was taken as 75% of the breakers' capacity because wire size is typically chosen as the next largest size accounting for 125% of the rated load. Given the diversity of loads in a home, this approach is likely a conservative one. In actual practice, the number of free breaker spaces is also a consideration in a home's capacity for more loads, but because subpanels can be added to the main panel at moderate cost, overall capacity is more critical and was considered in this study.

Figure A-2. Example Panel Photograph

Source: Guidehouse analysis

After first considering the state of the panels and their capacities as the team found them, the team then added heat pumps sufficient to cover the whole home with heat pumps for heating. Calculating actual heat losses of homes was beyond the scope of this study and beyond the means of the collected data. To approximate the capacity and therefore amperage of heat pumps, the team used a rough rule of thumb of 1 ton of heat pump heating per 450 square feet, 2 kW of power draw per ton at peak heating, and a power factor of 0.9. This rule results in roughly 0.02A per square foot of electrical capacity needed for heat pumps. Actual heat pump loads should be calculated using ACCA Manual J, and manufacturer data. However, this means of calculating capacity roughly matches the team's field observations of heat pump installations and the capacity needed.

Appendix B. Supporting Data

The supporting data for all end use load shapes is included in the attached spreadsheets. The statistics for each value are also included within the spreadsheets.

Table B-1. Appendix B Supporting Document File Names and Contents

File Name	File Type	Contents
Appendix B-1 Saturation and Characterization Results Plots	PDF	Detailed plots of saturation and quantity of all end uses by end use and demographic; existing and new unit efficiencies and other characteristics
Appendix B-2 MA Statewide Saturation Results	Excel	Proportion of homes with end use and average quantity per home by demographic
Appendix B-3 MA Statewide Characterization Results	Excel	Distribution of age, efficiency, and capacity by end use and demographic

Source: Guidehouse