BRINGING RENEWABLE THERMAL SOLUTIONS TO SCALE IN NEW ENGLAND

Activity 2 – Analysis of Local Markets

Report submitted to the Carbon Neutral Cities Alliance

By Meister Consultants Group, Inc.

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SECTION 1 INTRODUCTION

Activity 2 of the CNCA New England project involves analyzing the markets of the five Participating Cities (Boston, Somerville, Northampton, Portland, and Providence) to assess opportunities for residential renewable thermal technology deployment. The three primary tasks of Activity 2 include:

- **Market segmentation analysis** of the residential housing stock of each of the participating cities to identify optimal prospects for renewable thermal technology deployment;
- **Customer insights analysis** of residents of the five cities who have been identified as optimal prospects to identify attitudes towards renewable thermal technologies with a focus on air source heat pumps (ASHP); and
- **Assessment of soft cost reduction opportunities** for renewable thermal related to municipal regulations and processes.

The outcomes of these tasks aim to provide municipal leaders at the Participating Cities and beyond with resources to improve the targeting of outreach and education efforts related to the renewable thermal campaigns (Activity 3) and future programs, as well as to identify opportunities within municipal jurisdictions to directly and indirectly reduce renewable thermal installed costs.

This interim report provides results and preliminary key findings from the completion of these tasks. It is expected that these key findings will be refined and integrated into the final report upon completion of the full project scope of work.

SECTION 2 MARKET SEGMENTATION ANALYSIS

The market segmentation analysis aims to identify optimal residential (one- to four-family) prospects in Boston, Northampton, Portland, Providence, and Somerville for the adoption of renewable thermal systems. Meister Consultants Group (MCG) developed an index with which to measure the technical and economic suitability of these residential buildings for the installation of several renewable thermal technologies. The index considers existing heating and cooling systems, heating fuel types, and a range of other building attributes and demographic information derived from publicly-available data sources, including tax assessor databases, building permit databases, and census data from the American Communities Survey.

The renewable thermal technologies assessed include four of the five technologies originally discussed in the scope of the project:[1] ground source heat pumps (GSHP), air source heat pumps (ASHP), pellet boilers, and solar hot water (SHW).

- Given the variety of applications possible for split ASHP—i.e. whether the system is ductless or ducted (central)—and the relevance of building attributes to their suitability, ASHP were treated as separate technologies for purposes of this analysis. Also, given that ductless ASHP can be installed to displace a wide range of the existing heating/cooling load (e.g. 30%-80%+), ductless ASHPs were assessed as near whole-home replacements in this analysis.
- Additionally, heat pump water heaters (HPWH) were included in the assessment at the request of the Participating Cities.

The completed index includes all one- to four-family residential parcels, ranked based on their suitability for each of the six renewable thermal systems. Maps were created to help each city visualize the spatial orientation of these parcels. This index may be used by the Participating Cities to support the outreach, education, and purchasing campaigns to be completed under Activity 3, and to accelerate renewable thermal technology adoption within their jurisdictions through other programs. The index results could:

- Enable the cities to better understand the opportunities for various renewable thermal technologies across their residential buildings
- Inform cities of the optimal renewable thermal technologies for each of their residences;
- Identify individual households, clusters, or high-potential neighborhoods to target delivery of outreach and education materials (e.g. through print materials like mailers or door hangers or through IP/geo-targeting of online ads); and

[1] Biodiesel was not assessed as part of this task due to the limited applicability: biodiesel is blended into heating oil and requires no additional technology deployment. Thus, in initial scoping with the participating cities in December 2016, biodiesel was de-prioritized for purchasing campaigns.

- Provide contractors serving city campaigns with resources to streamline the process of customer acquisition or open up opportunities to establish other partnerships with contractors.

The final indices and maps were provided to the Participating Cities. A sample of these maps are provided in Appendix 1.

2.1 INDEX DESCRIPTION

The Suitability Index is a calculated value that considers the technical suitability of installing a given RH&C technology for each residential parcel in a city. The index comprises several building criteria (e.g. year of construction, current heat fuel type, etc.), each of which are weighted based on their relevance to the installation of each renewable thermal technology and calculated for each parcel. Because the suitability index is technology-specific, different indices were developed for each of the six renewable thermal technology types, as not all criteria are equally relevant to each technology. Furthermore, three variants of the index were created for each technology to account for each city's demographics:

- **A site suitability-only index,** which considers only physical characteristics of a building.
- **A likely adopter index,** which combines physical characteristics with socio-economic characteristics (i.e. home ownership and neighborhood income) to emphasize homeowners who are more likely to purchase the technology.
- **An equity-focused index,** which combines physical characteristics with socio-economic characteristics (i.e. low to moderate neighborhood income) to identify high-quality homes that may face financial barriers to adoption and could warrant dedicated outreach (e.g. via income-eligible programs or targeted messaging).

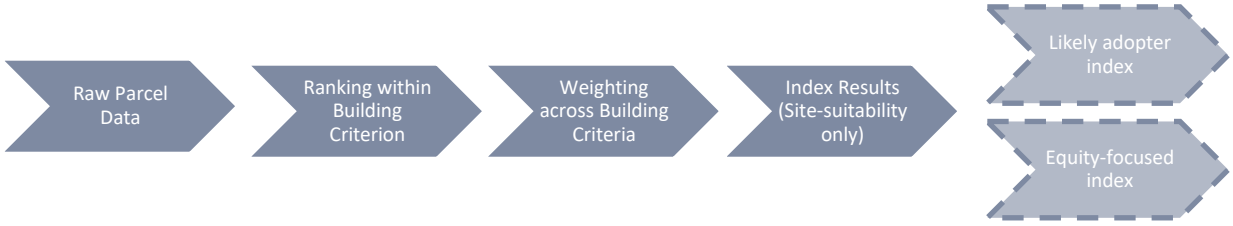
Figure 1 illustrates the procedure for creating the Suitability Index.

- The index starts with raw data for each parcel in the cities of interest. Parcel level data were obtained from each city's tax assessor and building permit databases.[2]
- Next, data within each criterion are assigned a qualitative ranking scheme to reflect how variation in that data field impacts the suitability of the technologies. For example, homes heated with gas are assigned a low score (which reflects that the home is a poor candidate for renewable thermal conversion due to challenging economics), homes heated with oil are assigned a medium score, and homes heated with electricity are assigned a high score.
- Given the differences in installation and function of each technology, some of these ranking schemes may vary from technology to technology

[2] The reliability of tax assessor data varies from city to city, especially as it pertains to heating systems, given that the information collected is primarily focused on providing an assessment of the home's value. Building permit and census data were used to refine information derived from the assessor's databases, but there are no other publicly-available data sources that provide comprehensive information about every building parcel in a city. Utility data could be more accurate (e.g. to identify customers heating with electric resistance or to identify all gas customers within a city), but cannot be made publicly available due to consumer privacy concerns.

- Each building criterion is weighted relative to the others to reflect importance in the final Suitability Index.
- Income data were incorporated to create two additional indices: the likely adopter and equity-focused indices.

Figure 1. Procedure for creating the Suitability Indices



Each technology has separate ranking schemes specific to the building criteria that affect the suitability of the technology. For example, the current heating distribution system in a building is a more important factor for a building's conversion to a ducted ASHP system (which requires an existing forced-air distribution system) than for a conversion to a ductless ASHP system (on which distribution system has no impact). Table 1 illustrates the available criteria data types and their relative rankings for each technology. These rankings are weighted for the final index value. Within each city, the scores for each technology can be compared to each other (though not across cities).[3]

2.2 INDEX RANKING ASSUMPTIONS

The assumptions built into the index were validated through desk research and via interviews with technology manufacturers and installers.[4] The following preliminary assumptions (in no particular order) affected the impact of each building criteria on the Suitability Index for each technology:

- Parcels examined in this analysis included **single- and multi-family homes up to four units**, as well as condominiums in buildings of up to four units. Single-family buildings are ranked higher than condos, which are ranked higher than multi-family buildings, due to potential difficulties with making building modifications that involve co-owners or shared spaces.
- Parcels were ranked based on **how recently their heating systems were replaced**. This information was sourced from building permit records.[5] Where permitting data were unavailable, the year the building was constructed was used as a proxy. Homes built or with heating systems replaced over

[3] In each assessor database, some parcels do not have complete building data used for developing the suitability index. Parcels that are missing data fields are included in the analysis but are de-prioritized.
[4] Organizations interviewed included Chaves Heating and Air Conditioning and Aztech Geothermal. MCG has also engaged with heat pump manufacturers (e.g. Mitsubishi Electric, Stiebel Eltron) over the course of the project.
[5] Though permitting regulations differ based on the municipality, the installation of HVAC technologies typically requires pulling a building permit. See Section 1.3 for additional discussion on permitting for residential renewable thermal installations.

10 years ago were ranked higher than those between 5-10 years ago, which were ranked greater than those within the last five years.

- **The current heating distribution system** was a key building criterion used to determine which RH&C technologies were suitable for each building. The ranking of the heating distribution system varies for each technology assessed. Table 2 shows an example of the ranking scheme for the renewable thermal technologies that provide space heating and cooling.
- **The current heating fuel** was used to determine how likely a building is to transition to RH&C technologies based on economics. Homes heated with electricity were given the highest rank, followed by those heated by oil,[6] with the lowest rank assigned to those heated by natural gas or existing renewable technologies (e.g. solar, heat pumps).
- **The current air conditioning (AC) system** was used to determine how likely a building is to transition to heat pump technologies, which can provide both heating and cooling.[7] Homes that have no AC system in place were given the highest rank, followed by those that use window AC units or central AC, and the lowest rank was assigned to buildings that already have a heat pump.

[6] The small number of homes heated by coal or wood (assumed to be wood stoves were included in this category as well.

[7] Approximately 80% of homeowners who have installed an ASHP under the MassCEC Clean Heating and Cooling program had no AC system in place or replaced window units.

Table 1. Weighting scheme used for the design of the Suitability Index.

Criteria are weighted differently for each technology, with the number of + signs indicating level of influence (i.e. + indicates low weight, +++ high weight, - no weight).

Data Type	Technology					
	Ductless ASHP	Ducted ASHP	GSHP	Pellet Boiler	HPWH	SHW
Living Area (ft^2)	-	-	+++	-	-	-
Basement (Y/N)	-	-	-	+++	+++	-
Lot Size (acres)	-	-	+++	-	-	-
House Type (SF/MF)	+++	-	+	++	+	+
Stories	++	-	-	-	-	-
Average Room Size	++	-	-	-	-	-
Heat Distribution Type	+++	+++	+++	+++	-	-
Fuel Type	+++	+++	++	++	++	+++
Gas Line Proximity[8]	++	++	++	++	++	++
Build/Heat Replacement Year	+	+	+	+	-	-
AC (Y/N)	+	+	+	-	-	-
Income[9]	++	++	++	++	++	++

[8] A parcel's proximity to gas lines was not included for Northampton, due to the city's gas connection moratorium.
[9] Income was only incorporated for the income-adjusted Suitability Index

Table 2. Heating distribution system

Different renewable thermal technologies that provide space heating and cooling will be more suitable for different distribution systems. Distribution systems that are well-suited to the technology are indicated with a +, while those that are not suitable are indicated with a -.

Current Heating System	ASHP, Central[3]	ASHP, Ductless[10]	GSHP[11]	Pellet Boiler[12]
Electric Baseboard	-	+++	-	-
Floor Furnace	-	+++	-	-
Forced Air	+++	+++	+++	++
Hot Water/Hydronic	-	+++	+	+++
Radiant	-	+++	+	+++
Steam	-	+++	-	-
Hydro-air	-	+++	-	+++

- **Whether the building has a basement** was used only for HPWH and pellet boilers, because those technologies require extra space (beyond that which is typically required for conventional space heating or domestic hot water technologies) for air circulation and bulk pellet storage, respectively. Where data for presence of a basement were unavailable,[13] a proxy was used to determine if there is at least 500 ft^2 of comparable indoor, non-living space in the house.
- Due to the necessary **outdoor area** for drilling vertical wells and/or trenching horizontal systems, **parcels with larger lots** are more suitable for installation of a GSHP system than parcels with smaller lots. The ratio of the home square footage to the lot, as well as how many stories a home has, dictates whether ground source heat pumps are a viable option (including both horizontal and vertical systems). Additionally, the particularly high upfront cost of GSHP systems has limited most installations in Massachusetts to larger homes with higher heating and cooling loads, due to the high capital cost.[14] Homes smaller than 1500 ft^2 are considered too small for GSHP installations. Above 1500 ft^2, homes that are progressively larger are assigned a higher rank.[15]

[10] *This information comes from an ASHP installation interview with Manny Chaves of Chaves Heating and Air Conditioning on March 10, 2017.*
[11] *This information comes from a GSHP installation interview with John Ciovacco of Aztech Geothermal on March 7, 2017.*
[12] *Biomass Wood Pellet Boilers Pros and Cons. EcoHeat Solutions.* http://www.ecoheatsolutions.com/heatingsolutions/woodpelletboilers/
[13] Only Portland had data for presence of a basement in the tax assessor dataset.
[14] The average square footage of homes that have installed GSHP through the MassCEC Clean Heating & Cooling Program is 3,465 ft^2.
[15] *A Buyer's Guide for Residential Ground Source Heat Pumps. Canadian GeoExchange Coalition. (2009)* http://www.hydroquebec.com/pdf/en/Guide_achat_geo_exchange.pdf

- Homes that are taller than approximately three **stories** are not well-suited for a ductless ASHP installation, due to constraints on distance from the outdoor unit to the indoor unit related to line set.[10] For that reason, very tall buildings were ranked lower for ductless ASHPs. Furthermore, the average room size was considered for ASHPs suitability, given that homes with many small rooms are less suited for ductless ASHPs than homes with fewer, larger rooms and open format floor plans.[10] Therefore, homes with a ratio of rooms to stories greater than three are ranked lower.
- The **building's proximity to gas lines** (i.e. within 200 feet of a home with gas heating) affected technology suitability, as the building owner is likely to convert to gas from their existing heating system. In general, homes that lack access to gas are likely to be excellent candidates for RH&C. As data on gas distribution networks are not available, distance from the nearest gas-heated home was used as a proxy for distance to gas distribution pipelines. This criterion was not included for Northampton, due to their utility's moratorium on any new gas service connections, regardless of whether the home already has an existing gas account.
- For Northampton, **EnerScore** grades were incorporated into the Suitability Index.[16] Homes with an A or B were assigned the highest rank, followed by those with a C or D, and those with an E or F were given the lowest rank.
- The two market segments of the income-adjusted Suitability Index are the **likely adoption group** and the **equity-focused group**. The adjustment was performed using **income data** from the census. Because the census is done on the block group level, while the rest of the technical building criteria used in the Suitability Index was done on the parcel level, a probability function was used.
    - **Likely adoption households** are those which have greater than 50% likelihood of earning over $60,000 per year, and are owner-occupied. Higher probabilities are favored over lower probabilities. Owner-occupied homes were identified either by information already included in the assessor database (for Boston and Providence) or by matching building addresses to building owner mailing addresses to establish a proxy.
    - **Equity households** are those which have greater than 50% likelihood of earning less than $60,000 per year. These households do not need to be owner-occupied, and are given equal preference regardless of income probability above 50%.

[16] Northampton previously completed a project with EnerScore to assess the quality of a home's building envelope based on a similar public data set. Homes that received a score of A or B are considered to be high-performance homes, and homes that received Mass Save-approved weatherization upgrades tended to score between B and C.

2.3 KEY FINDINGS

This section describes high-level key findings across all five participating cities from the Suitability Index results. For more details on each city's findings, please refer to the index dataset. It is expected that additional/revised key findings will be provided in the final report once outputs from this analysis are integrated into campaign planning.

It is worth noting that this analysis focuses **primarily on building criteria as opposed to economics**. While the suitability of some of these criteria for various renewable thermal technologies involve system economics (e.g. no renewable thermal technology is cost-competitive with natural gas, changing the existing heating distribution system is cost prohibitive), this analysis does not scale technology suitability based on expected payback nor does it compare the relative cost-effectiveness of each renewable thermal technology against each other, due to the variability of cost-effectiveness based on location, building type, and available incentives.

- Across all five participating cities, ductless ASHPs and pellet boilers tended to emerge as the most suitable technologies (Figure 2). It is worth noting, however, that this index assessed the suitability of (near) whole-home ductless ASHP installations ("replacement applications," e.g. 3+ indoor minisplit heads) to provide a more direct comparison to the other technologies. It is expected that many more homes are likely to be suitable for some displacement application (e.g. 1-2 indoor heads).[17]
    - In Boston and Somerville, ductless air source heat pumps are a top candidate for at least 50% of one- to four-family homes.
    - In Northampton, Portland, and Providence, pellet boilers are a top candidate for slightly more homes than ductless air source heat pumps. This is likely due to the higher percentage of single-family homes in these cities (85%, 78%, and 51% respectively) compared to Boston and Somerville (21-22%).
    - Ground source heat pumps and ducted air source heat pumps are top candidates for approximately 6-12% of each city's one- to four-family residential homes. For GSHP, it is expected that this is due to the lower space available in urban housing for drilling/trenching, and for ducted ASHP, this is likely due to the prevalence of hydronic and stream-based distribution systems in these cities.
- Across all five participating cities, HPWH are a top candidate for over 60% of each city's one- to -four-family residential homes (Figure 3).
    - Somerville has the largest percentage of homes for which SHW is a top candidate, at 35%.
- In Boston and Providence, residences that are good candidates for ductless air source heat pumps tend to be clustered toward the outer areas of the cities. However, in Northampton and Portland, buildings that are good candidates for ductless air source heat pumps tended to be more

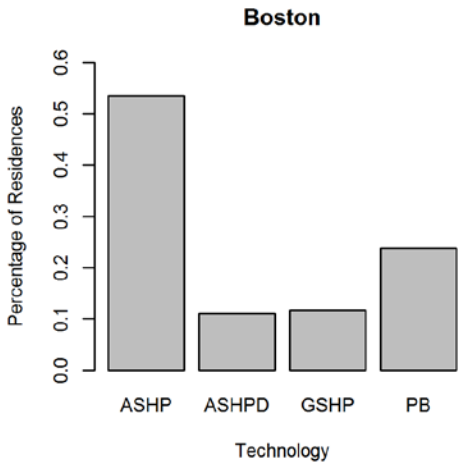
[17] Over 60% of ductless ASHP installations completed through the MassCEC Clean Heating and Cooling rebate program (for December 2014-August 2016) involved one or two single-zone units.

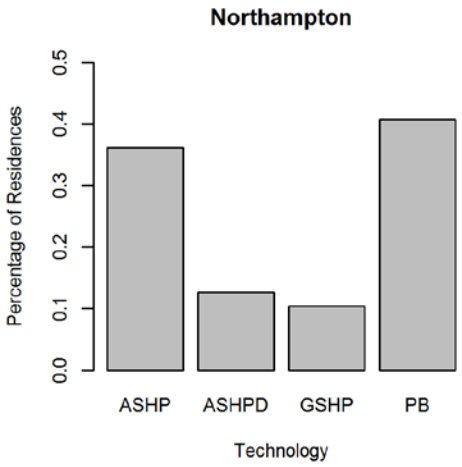
concentrated near the center of the cities. This is likely due to the prevalence of rental units in the center of Boston and Providence with greater owner-occupied homes in the outer areas of the city. By contrast, in Northampton and Portland, more homes are expected to be single family in the outer areas of the city (compared to more condos and 2-4 family buildings in the center of the city), which could be more favorable to pellet boilers.

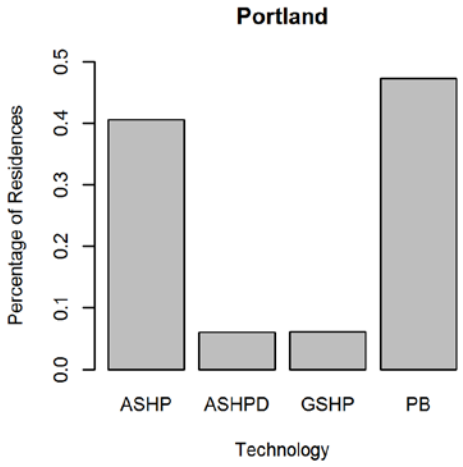
- For domestic hot water, HPWHs tended to emerge as the "best fit" technology given the lack of roof-related constraints (e.g. installing systems on shared rooftops can be more challenging than in shared basements). However, there are significantly greater limitations to the suitability indices for assessing solar hot water suitability compared to the other renewable thermal technologies, as insolation maps and data for each city's housing stocks were not available for comparison. Lack of comparison of renewable thermal system economics particularly limits the value of this approach for domestic hot water applications: Massachusetts provides significantly greater rebates and tax incentives for SHW than in Rhode Island and Maine.

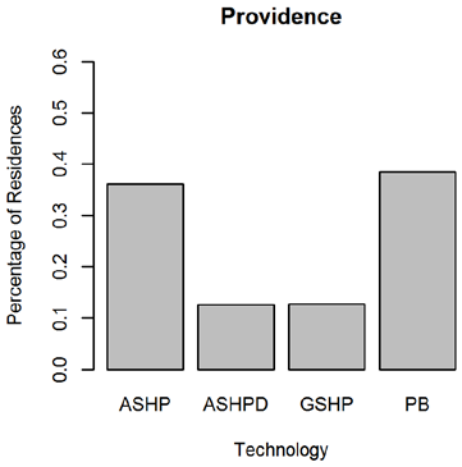
Figure 2. Renewable Thermal Technology Comparison: Space Heating and Cooling

Prevalence of residences for which the following technologies are the "best fit" for renewable thermal systems. ASHP: ductless air source; ASHPD: ducted air source; GSHP: ground source heat pumps; PB: pellet boilers


Boston
Percentage of Residences
0.0
0.1
0.2
0.3
0.4
0.5
0.6
ASHP
ASHPD
GSHP
PB
Technology


Northampton
Percentage of Residences
0.0
0.1
0.2
0.3
0.4
0.5
ASHP
ASHPD
GSHP
PB
Technology


Portland
Percentage of Residences
0.0
0.1
0.2
0.3
0.4
0.5
ASHP
ASHPD
GSHP
PB
Technology


Providence
Percentage of Residences
0.0
0.1
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ASHP
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GSHP
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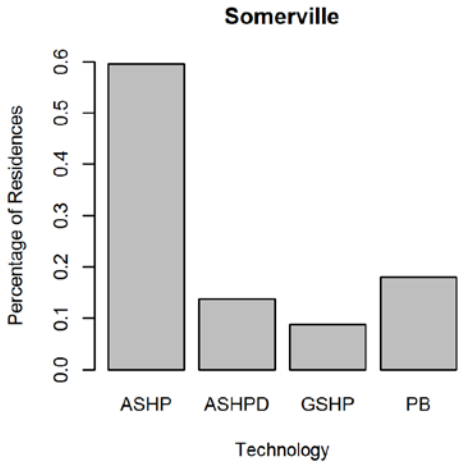
Technology


Somerville
Percentage of Residences
0.0
0.1
0.2
0.3
0.4
0.5
0.6
ASHP
ASHPD
GSHP
PB
Technology

SECTION 3 CUSTOMER INSIGHTS ANALYSIS

The following section highlights the findings of a qualitative research project exploring awareness and impressions of ASHPs among a subset of New England homeowners.[18] These respondents were recruited from a list of homeowners across the Participating Cities whose homes scored as "likely adoption households" (see Section 2.2) for ASHPs.[19]

Fourteen (14) respondents[20] were screened, recruited and interviewed from mid-March to early April 2017. A snapshot of the respondents is provided below:

- **Gender breakdown:** Men (9) and Women (5)
- **Age mix:** Half are age 36-59, half are age 60+
- **Geographic mix:** Boston (3), Northampton (3), Portland (3), Providence (3), Somerville (2)
- **Housing type:** Single family (9), Condo (4), Multi-family (1)
- **Primary heating sources:** Oil (7), Natural gas (4), Electric (3)
- **Air conditioning status:** Central (3), Window units (4), No AC (8)
- **Household income:** Less than $60k (6), $60-100k (8)
- **Education:** 2-year college (1), 4-year college (4), Graduate/Masters/JD (7), PhD (2)
- **Household size:** One person (6), Two people (6), Four people (2)
- **Additional information:** Two households had children in college, one household is expecting a new baby

These interviews focused specifically on ASHPs due to: 1) the high suitability score of ASHPs relative to other renewable thermal technologies; 2) the interest of the Participating Cities in focusing their respective campaigns around ASHPs; and 3) greater range of existing state and utility incentive and outreach programs that include ASHPs. Likely adoption households were selected to target homeowners who would be most likely (and able) to purchase ASHP systems through the campaigns and to remove renters who are typically not in the position to make decisions around energy investments in their households.

This section is divided into the following sub-sections:

- **Section 3.1** – Key findings
- **Section 3.2** – Detailed findings
  - **Section 3.2.1** – (pg. 18) Experience with heating/cooling options and energy audits
  - **Section 3.2.2** – (pg. 25) Heating and cooling factors and considerations

[18] The focus of this qualitative research project was to identify sentiments, language, and attitudes of homeowners in each city who would be well-suited for ASHP (and thus the prime targets of city outreach and education efforts). Results from this project should not be aggregated for quantitative analysis.

[19] Homeowners were recruited from a list totaling 5,000 addresses that represented the most suitable parcels (under the likely adopter index) across each city. Additional screening of recruits was conducted to ensure data accuracy and to ensure that different homeowner attributes (e.g. heating fuel types, AC types, income levels) were represented.

[20] See Appendix 2 for descriptions of the interview respondents.

3.1 KEY FINDINGS

This section provides key findings from the conducted interviews.

The outlook for widespread Air Source Heat Pump usage in New England homes is positive:

1. There is very low overall awareness of Air Source Heat Pumps. Many have never even heard the terms "heat pump" or "mini-split." This is a definite challenge – homeowners need a very good reason to investigate a technology change that will affect their biggest financial investment. However, because there is such a void of knowledge, cities have significant opportunities to shape how and what people learn about ASHPs.

2. Most people without direct knowledge of the technology benefit from a very basic explanation of how ASHPs work. Without a personal testimonial or hands-on experience through with a friend or neighbor's system, most homeowners need at least a rudimentary description and explanation of how ASHPs work. In particular, consumers should learn that ASHPs run on electric power, work like refrigerators to transfer heat in and out of buildings, and can be installed in a home with or without ducts.

3. Homeowners lacking air conditioning find ASHPs very intriguing once they learn of the dual functionality. The desire for AC can encourage homeowners to investigate and install a heat pump in their home. Not surprisingly, Mainers are much less likely to care about air conditioning compared to Massachusetts and Rhode Island residents.

4. There is a lot to like about heat pumps. In addition to air conditioning, the most attractive aspects of ASHPs are lower energy costs, energy efficiency, improved technology for cold weather operation, and eco-friendly operation. Saving money on home energy costs is what appeals most to the clear majority of homeowners.

5. Awareness of energy audits is high and many have taken advantage of this service. Opinions of audit providers like those working through Mass Save are very positive. Homeowners consider energy assessment providers trustworthy and credible on home heating and cooling options because they are perceived as having no financial stake in the outcome.

6. Personal testimonials sell ASHPs. Homeowners who have adopted ASHP technology or are considering it all know about heat pumps via friends and neighbors that have them. Those who have even cursory knowledge of heat pumps have learned it from people they know. Other key information sources include utilities and utility programs like Mass Save, energy and equipment dealers, home energy contractors and

internet research. Homeowners rely less on government sources for information about home energy options.

7. Homeowners follow recommendations from their trusted sources, especially personal connections. They are likely to use endorsed contractors for installation, though most will still seek around three bids before planning a major project.

8. Incentives help soften the upfront costs of ASHP technology. Cash rebates are the most desirable incentives, but low financing and tax credits reduce the expect time to recoup homeowners initial outlay for a heat pump system.

However, there are some major hurdles blocking extensive implementation of ASHP technology:

1. Cost drives decision-making on home heating and cooling more than the environment. Cost is the primary consideration in most cases. This is true even among people who claim that the environmental impact of energy choices is very important to them. Interestingly, few homeowners have a solid handle on how much they spend on home heating and cooling.

2. The current low prices of oil and natural gas have dampened interest in alternative heating options. Interest in ASHPs is considerably lower among household owners with current natural gas systems or access to natural gas. Although some remember crazy fluctuations in home heating fuel costs from a few years ago, there is no current cost threat. In addition, people are used to dealing with oil monitoring and maintenance and natural gas is easy with relatively low risk. Risk-averse homeowners are likely to stick with what they know.

3. Electric heating has a bad reputation in New England and is relatively uncommon. Homeowners perceive that electricity is expensive and assume that all electric heating is inefficient. As a result, the true cost of running an Air Source Heat Pump is a persistent question.

4. Consumers have a lot to learn about ASHPs. Most of their questions are around cost, but they also wonder about reliability, the equipment and installation process and where you would go to find out more or potentially buy a heat pump. Cold weather operation and equipment that requires snow removal raise questions that are best answered by installers, dealers and other heat pump owners with reassurances.

5. The concept of using dual systems requires more education. For some New Englanders, the idea of having two or more home heating sources makes sense. Many already have multiple energy sources in their homes for cost savings, comfort, convenience or emergency backup. Others do not understand the redundancy and need an outline of the benefits. Another issue is education around proper usage of multiple sources; few understand how or why one would operate a heat pump in conjunction with an oil burner, rather than just in the shoulder seasons or as an air conditioner.

6. Owners in historic neighborhoods and some condominium buildings face additional challenges to considering ASHP technology. Major changes in condos often require a plurality of residents to agree, and changes that require special assessments on condo owners can be particularly contentious. Alterations to

historic buildings usually demand approval from various historic designation entities. There are also legal implications to consider in most condo communities.

Conclusions and Recommendations:

- **Market heat pumps as an energy efficient, cost effective and convenient alternative that is also an eco-friendly option.** Environmental impact is a bonus, not the main reason most people install heat pumps.
- **Focus on "affordable AC" to get ASHPs into homes, especially those without natural gas.** In the current price environment, it does not make sense to use resources to pursue conversion in homes with natural gas – unless they need air conditioning. The best targets are homes with oil, propane or electric heating AND a need for AC.
- **Cultivate environmentally-focused consumer groups who can bring ASHP technology to neighborhoods.** Word of mouth testimonials sell heat pumps better than anything else. Community groups can organize to share information about ASHP technology, available incentives, contractors, best usage practices and bulk installation discounts. If possible, build off of previous "Solarize" programs to reach out to homeowners who have installed or considered solar PV: solar knowledge, interest and usage all correlate closely with heat pump appeal.
- **Optimize information provided by key sources.** After seeking input from friends and neighbors, potential heat pump customers will look to utilities and utility programs like Mass Save, energy and equipment dealers and standard internet research. Efforts to enhance and clarify the information provided by these sources is advisable. Home energy audits offer a particularly important opportunity. Through outreach campaigns, cities could consider maximizing exposure to customer testimonials—e.g. through in-person presentations/Q&As at events, open house visits—in addition to providing clear, reliable information on campaign websites.
- **Give consumers want a "cost to operate" calculation.** Even though few know how much they currently spend on home heating and cooling, they want to know how much they could save with a heat pump. Having a number ("dollars a day" or "dollars a month") helps them justify making an eco-friendly choice for home energy that requires a significant upfront investment.
- **Provide homeowners who install ASHPs with better education around how to use them.** Dealers and installers need training in consumer education around ASHP technology and usage. Internet resources such as YouTube videos could also be developed to help consumers optimize their use of new heat pumps.
- **Make condos a secondary target.** While from an environmental perspective targeting condo buildings for ASHPs seems obvious, the challenges of dealing with condo requirements and boards will undoubtedly slow the adoption rate for the technology. Condo conversion should be a lower priority until a specific plan can be developed for identifying and soliciting optimal buildings as well as addressing structural, historic, governing board and legal needs.

3.2 DETAILED FINDINGS

3.2.1 EXPERIENCE WITH HEATING/COOLING OPTIONS AND ENERGY AUDITS

Home Heating Energy Sources

Many New Englanders use oil to heat their homes. Owners consider oil reliable, safe and right now, relatively inexpensive. Most do not think about switching their home heating to a different fuel. Their burners are solid and last a long time. A younger Providence man remarks, "It's dependable. It has never been replaced in 70 years. It also keeps the house good and warm."

> We have a new German boiler which is terrific, probably saves me about 30% on an annual basis. What I like best is the forced hot water aspect of it. House is not dusty. House was built in '62. And the units are cast iron which you can't even buy anymore. It's an efficient system for oil. (#4)

> At the time we got this house, there was less demand for oil so we felt less secure…Not that there is a large likelihood, but there is less possibility of explosion than with gas. And it's less expensive than electric heat would be. (#6)

> The price is pretty cheap right now. The house had oil when I bought it two and a half years ago and I haven't had the money to do a conversion. I'm thinking about going to natural gas, but honestly because of the cost of the two fuels right not, oil seems to be a little cheaper. So that in combination with the cost of the conversion, we're not in a huge rush. The change is primarily cost-driven, and if you do it right, it can be a little cleaner, at least that's my perception of the issue. (#7)

> When we bought this house – this is our second home – the guy that came over to service the burner said that it's a very efficient burner. That made me feel good. The system is about 10 years old. (#10)

The main knocks against oil heat are maintenance and monitoring and cost fluctuations. "It's more expensive than natural gas," notes an older Northampton man. Another Northampton man adds, "One disadvantage is no ducts for central air, but I don't really care about that." Not many homeowners express regret on the environmental impact of using oil, though an older Somerville man is the exception, "It is petrochemical based and if there was a way to heat without dependency on petroleum that would be good."

> I'm dependent on oil delivery, so I have to be mindful of monitoring the oil tank and the price of oil and when to get a fill. I used to have gas when I had a condo and that was so easy. I never had to think about refilling and the cost of gas was very inexpensive. I liked how my clothes came out of the dryer; that's not the case with an electric dryer. (#2)

> Not that easy to deal with because you have to maintain it properly. Not many things I like about it, but it's been in the house since it was built. Oil prices have had some wild spikes. It's not bad now, but when it was

> really high, it was close to $4 a gallon. It also can take a long time to heat up if you've been away. It takes its time to heat up the cast iron radiators and they all weigh an enormous amount. (#5)

> (Despite having an efficient burner), we still use a lot of oil anyway, because we have a lot of windows and they are very drafty. (#10)

> Oil is a fossil fuel – not that natural gas isn't – but there are certain environmental downsides. The other big issue is that the cost can fluctuate, it's unpredictable. My sense is that the cost of oil fluctuates more than other heating fuels. (#7)

New England homeowners also like heating with natural gas. They describe it as "easy," and "cheap," especially compared to oil and electricity. They must try hard to come up with negatives, and usually only the relatively small potential danger for explosion is mentioned.

> I like the forced hot water aspect of my system. It's on demand, it doesn't dry you out, it's very reliable and on a circulating loop. There is no external tank. (#9)

> I live in a condo system and it's the only source of energy I'm aware of. I had oil heat growing up. I'm fine with it. (#13)

> There could be a safety issue – if there was a gas leak that could be dangerous and it's not easy to detect. But I've never experienced that. (#13)

Since electric heat is not all that common in New England, some have negative impressions of it. However, those who have tried it are generally pleased. Some have even embraced electric heat as part of a multi-energy source system.

> I live in a super well-insulated home so we have very low energy needs. We also have backup baseboard electric heat, a small wood stove. We have solar hot water, which heats our domestic hot water but also a solar hot-water fed radiator in the main living area. We live in an absolutely amazing house that we designed and built, primarily around energy efficiency. (#12)

> I have an electrical heating system – electric baseboards. I'll admit I was initially disappointed when I looked at this condo and it had electric heat. I guess my perception of electric was that it is not as efficient, so I had hoped this place would have had gas, a nice updated gas furnace. At the same time, it is easy, and it hasn't been as expensive as I thought it would be. It does heat up quickly, so I'm able to turn it down to 60 when I leave in the mornings during the heating season. I can turn it up when I get back from work and my bills have been low, so I have to say I've been pleasantly surprised with the way it works. (#14)

New Englanders Understand Supplemental Heating

Supplemental heating is not a foreign concept for New England homeowners. Most understand and many take advantage of at least one supplemental heating source. Pellet stoves and wood burning stoves are popular. The downsides are mess and the need to haul wood or heavy pellet bags.

> I have a pellet stove, which I love. I have a fireplace insert in our living room. It is very comfortable, warm heat. It's nice. It's easy to operate and I think it reduces the amount of oil I use. It's like having a fireplace with having to cut up all the wood. The only disadvantage is I have to clean it and it's not a very pleasant task. It's dirty and there's a lot of soot. (#1)

> I augmented my system with a pellet stove – an insert in my fireplace. You have to carry pellet bags that weigh 40 pounds a piece and move them around. In the winter when there is snow on the ground, you have to go out to the garage and carry pellets into the house. If you leave the house for a few days, you have to depend on oil alone. (#5)

> I have several fireplaces, I will burn wood. I don't use this as a main heating source, just a supplemental on a very limited basis. More for effect than anything. (#9)

Many homeowners use space heaters. These serve to "take the chill out" of certain rooms and in some cases, lower costs for primary heating. A younger Portland man explains, "Yeah, we use an electric space heater…if there's a chill in the living room, just come in and turn it on. Ten minutes, get the chill out, that way we don't have to crank up a whole zone." A younger Portland woman adds, "We have space heaters built into the walls in the bathroom and we use them in the winter when we shower." A younger Providence man notes, "We have a space heater that is in the basement but I rarely get it out."

> I use a space heater in the living room and also in the bathroom so I don't use as much heating oil. I'm heating just a few areas to cut down on my heating bills. (#2)

> Sometimes I use a portable electric heater. I don't use it that often. Maybe three to four times a month. (#3)

> There's also electrical heating systems. We have space heaters we use when we're not close to the fireplace. Electrical is also an option for us. (#5)

> I think some other units in my buildings get very cold and have to use supplemental heating. I think they don't have the proper storm windows. (#13)

A few homeowners have added supplemental heating sources as backup to their primary heating. An older Northampton woman describes, "I did add a propane generator for when the power goes out. If I had a power outage I wouldn't lose the electricity." A younger Portland woman adds, "We like a wood stove, and it also provides a way to keep the house warm in a power outage."

When asked about supplemental sources New Englanders use, most think only of space heaters and wood burning stoves. An older Northampton woman acknowledges, "I'm not aware of other supplemental heating sources. I'd like to check into it but I'm not ready to replace my unit now. Maybe I should look into it, so that when the time comes I'll already be aware." A few have had exposure through friends and neighbors to heat pumps and mention these when asked about supplemental heating sources.

> If I was to either accompany or replace my heating system, those units that draw out the air from…what are they called? Heat pumps? A friend of mine has one in his house and he loves it. Actually two people I know have put them in…they use them as supplemental heat to their oil systems. I might look into heat pumps. They don't look that great but they are super-efficient. (#10)

> We considered adding a heat pump. We probably won't. They are very popular here and there are people arranging groups to buy them. We know lots of people who have them; we decided we really don't need it. We're gone 10-12 hours during the day in the coldest apart of the year and there is no added heat during the day. The heat is off or kept at a very low level on the baseboard thermostat. It rarely goes below 66 degrees. With the wood stove we can heat it fairly quickly and get it back to 70. The advantage of a heat pump is that if we don't want to deal with a fire, we could just turn it on and bring the temperature up. It would add a level of convenience. (#12)

Heating Budget

Heating bills for oil heat can range dramatically. Most homeowners do not have a good handle on how much they spend monthly for oil heat, because contracts tend to be annual or semi-annual. Some fill their tanks on an as-needed basis. Commodity prices also fluctuate. Homeowners are more likely to notice – or care – about the cost only when oil prices rise. Those who use multiple energy sources are even less likely to be aware of how much they spend on oil.

> My furnace is really old; it should be replaced but it works fine. I have an old house; like 60 years old. It's about 1200 square feet and it's a ranch. I really don't know (how much I spend per month on heating). (#2)

> Depending on the cost of oil…because we use the pellets, it's probably close to $100-$120 a month. (#5)

> In the winter we (spend) in the $6-700 range. (#6)

> I go through $800-1000 worth of heating oil costs in a year. (#7)

> Every time we get it filled, it's usually like $350 dollars; times that by like three to four times a winter. (#10)

> Monthly heating cost: For a year, I use between 4-500 gallons of oil. Right now, I spend about $100 a month. (#1)

The cost of heating with natural gas can be considerably less for most homeowners, but not always. One younger Boston condo owner who has natural gas estimates $70-75 a month for heating. A younger Providence man living in a single-family dwelling pays $200 or $250 a month.

> In the winter, I spend about $200 or $250 a month. We spend about $800 a month for 12 units. I think we pay all through the year, the same thing. The heat is a building expense – we don't pay individually for heat; it's part of our condo fees. (#8)

Some homeowners are finding ways to use electric heat cost effectively.

> The first year, with five people living here, it's about 2700 square feet and we keep it at about 70 degrees year round…even with the cost of the wood we burn and the electricity for the backup heat, we have natural gas for our stove and our dryer, and all of our energy costs for gas and electricity ran less than $3 a day. With the photovoltaics we are able to sell back some of the electricity to the grid but our power bill in the summer is under $20. In the winter, it's between $100 and $200 in the coldest months. A lot of people around here keep their houses cooler – their high temperature is lower than our low temperature. They keep the temperature at 65 degrees. I like it warm and we don't have to work very hard or spend much to do it. (#12)

> During the winter months, I average $140 a month, November through March. My first year it was more and maybe the cost of energy was more expensive but when I wasn't turning it down each day, it was more expensive – around $200 a month. (#14)

The Air Conditioning Debate

Many New England homeowners do not have central air conditioning. More than a few – especially in Maine – do not feel they need it. There just are not enough unbearably hot days to make these homeowners consider the investment. An older Boston woman remarks, "I don't have AC. Possibly I would get it but it's not a high priority item for me. I use fans."

> We don't really need air conditioning. Partly our climate, it's not very hot here, our houses are not very close together and we have great ventilation. A couple of weeks a year we use fans to circulate the air. We have 12-16 inches of cellulose insulation all the way around. It's what's sometimes called a passive house, or super-insulated house. So it stays warmer or cooler, it kind of moderates the temperature. (#12)

> If I was thinking of getting air conditioning for my entire building, I might think about (heat pumps), but I'm not. I wouldn't because I don't need it. Years ago, when I bought the building I thought, 'maybe I'll get AC for the 3rd floor,' but decided that for the amount of time it gets uncomfortable, it's just not worth it. (#9)

Some who use window units are satisfied. Most say they do not use their window units that much and are not willing to spend significant money on a system they would use minimally. A younger Providence man explains, "We use a window unit. No, I'm not really thinking about central air. We don't need it. For the handful of days a year we would want it, it doesn't outweigh the cost of it."

> We have a window one if we need it, but we often just open the windows. Never (thought) about getting AC; we might have only 1-2 days where we run the AC in the summer. Other than that, the house is in partial shade and it's usually quite nice. (#10)

> In the bedroom we put in a window unit if we feel we need it, maybe a couple weeks out of the year. I live in the Northeast, so it's not like living in the South; I wouldn't do it. (#9)

Others who have window units often complain about their noise, inefficiency and inconvenience.

> In the summer, sometimes I have a window air conditioner, sometimes not. It broke and I didn't replace it. I have a small apartment and I don't want to store it. I could use it but I don't really need it. If I were miserable for weeks on end, I would get an air conditioner. It's a couple of days out of the summer and I can live with it. (#8)
>
> We have been thinking about air conditioning. We have used window units in the past. But they're kind of noisy so we don't use them because they're noisy – that's the only reason we don't use them. We just don't turn them on. I have to take them out in the wintertime and put them away and they're heavy. (#5)

Other homeowners – especially in Boston – would like to have air conditioning, either for their own comfort or to add resale value to their high-end condos. Cost and feasibility hold most homeowners back. An older Boston woman remarks, "While it is not a high priority (for me), it is attractive. I think it is accurate to say that AC would help with resale value."

> Window AC; I can't afford central air – it's an old house. The window units don't really work well. I have sufficient windows in my bedroom but the bed would be too close to a window unit and it would be too noisy. I would love to have AC in my bedroom but it wouldn't work. (#2)
>
> We've been talking about AC ever since we bought the house, but the expense has kept us from doing it. We've seen neighbors do it, but we haven't done it yet. The house is old and is not prepared for the way things are nowadays, the duct work and all that. (#5)
>
> A broker asked me recently if there were any plans for the building to get central air. I said, 'not that I know of,' but I do think central air is a lot higher on people's priority. (#8)
>
> I haven't really thought about AC, because it's a brownstone so I'd have to retrofit a bunch of things. (#9)

Investigation of the possibility of air conditioning has led some to the heat pump alternative.

> We have a window unit we'll put in one room of the house; we don't cool the whole place. The older we get, the more likely we are to do that. Our oil company in fact does AC installation; we haven't actually spoken to someone about it but it's in the back of our minds. Our neighbors a few years ago got units they call 'Mr. Slims' [Mitsubishi ductless mini-split air conditioner/heat pump] I don't know if that's a brand…but there is a separate heat exchange outside and it uses exterior piping to go into small distribution units throughout the house and that's worked for them. We are living in an old house – it's 1890's – so don't want to tear it up too much to put ducts in. That seems like a reasonable solution, but we haven't gone so far as to ask anyone about what they could do for us. (#6)

> We all pay our own electrical bills. If you had air conditioning, people pay for it. Everyone has window units. There was this proposal which got no place because of the need to find a place for those twelve Mitsubishis. There's not enough room on the roof, it needs an easement if it's directly over someone's apartment and the people didn't want to give an easement. (#8)

> There is a unit in the wall. [Not a heat pump] It functions the same as a window air conditioner; it's a Wallmaster, a Freidrich. It works great. It's a small unit for a small condo with an open kitchen. There is only one window, so I'm very happy that I don't have to put an air conditioner in there and have a unit in the wall instead. It does a great job cooling the entire place down. Last June I replaced the one that had been there which was very, very old and obviously very inefficient. My bill got cut in half by going to an updated unit. I researched it on the internet. I knew what the previous make was, I wanted to utilize the existing sleeve in the wall, so took measurements and researched units that would fit that space. I looked at units (that had heating capability as well) but thought it would be redundant with my electric baseboard heating. The most important (factor to me) was being able to fit the existing sleeve, because I would have been looking at a more expensive install. After that, I was looking for something more efficient than the previous unit. (#14)

A few do have central air conditioning. A Providence man spends around $100-$150 on air conditioning. An older Northampton man describes how he runs his AC with renewable energy, "We do have central air, but I spend very, very little because I have solar panels. During the summer, I don't pay anything for the electricity. That's also a very efficient system; it's worked out very well. I use the AC a lot in the summer; I use about 400 kwh during the season but no bills from the electric company."

Energy Assessments Are Appealing

Most homeowners are aware of energy assessments or audits available through their states and utilities. However, most have not yet taken advantage of the offering. Many insist they will when they can find the time. A younger Providence man explains, "I do receive emails from the National Grid. I heard about it and I heard there are some free upgrades available. I think I'll explore it in the future." Another adds, "I am aware of what National Grid offers and have considered it and have the brochure; I just honestly haven't been able to find a day that I could be home to receive that service." An older Boston woman remarks, "What's really interesting is we have (an energy assessment) scheduled for the building for next week. They look at a sampling of the units (in the building)."

> I need (an energy assessment), but I haven't done it. [Knows about Mass Save program]. I know it would be beneficial. I'm just not sure I'll be able to afford the cost of the improvements. I know at some point there was a very good federal rebate for insulation which would benefit me, but there would be a cost in doing it. (#2)

> We have not had an official audit where they come out and tell you how efficient the house is at keeping heat in. There is a company in RI that does that but we haven't yet. It's free; it's a company called RISE. It's on our list (to do). (#5)

> Not in the past five years; a long time ago. I don't think we'll do it again. I'm aware (of Mass Save audits) but didn't think it would help. A long time ago we had cellulose insulation blown in and we've had some work done on our windows so I really don't know where else we would go for more savings. (#6)

> Not in the last five years, but I did do it before. It was NStar or someone like that who came out. That was maybe 10 years ago. I thought about doing it again because someone at work had Mass Save out and they gave him an offset for additional insulation. It's something I'm going to do. (#9)

Those who have undergone energy audits generally find them useful. Homeowners remember getting rebates on home improvements like adding energy efficient appliances and extra insulation.

> Yes, I have – through Mass Save. I'm very impressed with them. When they came, they thought the house was very well insulated and so they had very minimal suggestions. They did say I could get a rebate if I put more insulation in the attic, so I did that and it was nice – they paid like 75%. I have over 18 inches of insulation in the attic. I was happy about that Mass Save audit. (I knew about it from) the utility bill. They have a little enclosure that says, 'give us a call if you want to save energy.' It seems to me they know what they are doing. (#1)

A few homeowners are unaware of energy assessment programs. However, most are interested when they learn about them. A younger Somerville man notes, "No (I have not had an energy audit). I was not aware of (Mass Save audits). It seems like something I probably would and should do."

> No (we have not had an audit). I don't know too much about (what Efficiency Maine offers). [When described] Yeah, that would be something I'd be interested in. I can't afford to buy new windows right now – I've got two little kids in daycare – but if they were to hold up a meter and show me 'hey, you're losing a lot of energy out of the this window here; you should at least wrap it in the winter…' that would be useful. (#10)

3.2.2 HEATING AND COOLING FACTORS AND CONSIDERATIONS

Primary Consideration is Cost

When asked what is important to them if they were to replace their heating system, New Englanders are overwhelmingly focused on cost, particularly on the cost to operate the system. A younger Portland man wonders about the "bottom line cost out of my pocket – the initial cost versus savings. How many years will it take to offset the cost?" People are more likely to think about energy efficiency in terms of cost rather than conserving fuel or protecting the environment. A younger Providence man asserts, "(I care about) energy efficiency – that's related to price so that's the main factor for me." An older Northampton man agrees, "I'd be most interested in the efficiency of the system, and dependability. My boiler now which is about 13 years old, is about 87% efficient and I learned that the newer ones are 95% efficient. But now there's no reason to move up because I'd never pay for it." Even homeowners who value other factors in a

system usually come back to cost. A younger Somerville man remarks, "(Most important to me is) that it works well, and (my system) does heat up quickly. After that, it's just cost."

> I would stick with natural gas because of the cost. In the future, the oil prices might go down to almost nothing, or maybe solar energy will become popular. But I've never known anybody who uses just solar energy to heat their house. Those are future things, but not right now. (#3)

> How expensive would the change be? This house does not have ducts, so if you wanted to have forced air heating, what would you need to do and how much would it cost? If we were to look at something more contemporary – would it be worth it in the long term? The burner is huge. It looks like a great big snowman and it's cast iron. It's five and half feet tall and seven feet around. There are a bunch of pipes that come out of it and it takes up a lot of space. The cost of removing it would probably be a couple thousand dollars. It would probably be two days' work. Our neighbors have already done that so we have an idea of what it's going to cost. The new boiler is a lot smaller, about the size of a dishwasher. (#5)

Many homeowners emphasize reliability and are inclined to "stay with what they know" rather than switch to another heating source they know little about or have little experience with. Others would be willing to make a change when they replace their heating system, but feel they have few options, especially if they lack access to natural gas. Most are not well versed in heating options besides oil and gas. An older Somerville man says, "Cost would certainly be one. Energy efficiency would be a goal that would be nice to accomplish. I don't really see many non-petrochemical alternatives but if there were something like that, it would be something to think about."

> I'm not on a natural gas line. I have to have either oil or propane. The oil has been very good to me. I have a very efficient boiler and I'm happy with it. I've lived in this house for 43 years. The first boiler I had lasted 33 years and then I had a new one installed and I haven't had any problem with it. I have it serviced once a year and it's very efficient and works very well. I don't use very much oil. I'd explore going with propane; seeing what the cost was. (#1)

> I would not want to stay with oil. There are no gas lines leading to the area where I live. Newer homes nearby had that installed but gas is not an option for me. If there was an electric hybrid…I don't know what exists. I was told by the guy that used to maintain my oil furnace; he mentioned a high-tech option, cost efficient, reliable that he would recommend. I'm not sure if it was electric or if it was oil. (#2)

> We wondered whether we would keep the same type of system – what we would burn to heat the water in the radiators. If we're going to keep the same type of system, the newer oil burners burn at a higher temperature than natural gas does. It turns out when you're using natural gas, you're using twice as much natural gas to heat the same amount of water. So oil and natural gas end up costing about the same. Even though natural gas costs less. We do have natural gas in the house – we have a gas water heater, stove and gas dryer. We have a lot of options when it comes time (to replace our heating system). (#5)

Not many homeowners are likely to think about the environment as a primary factor. A younger Portland woman is unusual, citing her priorities as "Not using fossil fuels, efficacy – being warm, and keeping costs

down. I think I'd put them in that order." A few emphasize they are unlikely to change their heating system until it breaks and had to be replaced. An older Northampton woman explains, "The current system would have to be replaced. I would not do it just to save money, or because my current system might be inefficient. It's not the most efficient right now, but it's good enough, especially considering how old it is. I have the heat routed to the rooms I use the most." Other issues raised include convenience and esthetics.

> That I could regulate it to my own convenience. It's green and clean. It doesn't create a lot of dust. The energy saving is always important. (#13)

> I've mulled over getting a propane space heater, like a decorative one to heat up the living room. Esthetics is something that I've considered in the past. (#10)

Condo Owners Have Special Considerations

For many condo owners, temperature control in their units is a huge problem. Many older buildings have one heating system for the entire building, and condo owners often find themselves either too hot or too cold. There is little incentive to address wasteful heating when heating bills are paid through condo fees rather than connected to actual usage. An older Boston woman explains, "(Changing the system) is not any savings to me because the cost of the heat is to the building."

> Our condo building has only one zone; it makes it hard to regulate the heat. I often turn my radiators off because it's too hot. The cost of heating is paid through HOA fees. (#13)

> I have a condo. It's steam heat, it's old, there are 12 units in the building and we have one boiler for the whole building. I live in the front of the building which is much warmer than the back of the building. The back of the building faces the Charles River and it gets wind… the people in the back of the building are always complaining about being cold. We had the thermostat up to 74 degrees. In the front we get sun and protection against the wind. It is plenty warm enough – it gets too warm sometimes. We put in some Danforth valves, which has improved my situation a lot because I can actually turn off the radiator. The woman above me can turn off her radiators and on a frigid day have a room temperature of 77 degrees, which is too hot. I was so hot one time during a blizzard that I had to leave! There's an old guy in the back who has to use supplemental heating; he wanted the temperature in this apartment to be 75 degrees. For a while he had the sensor in his apartment and the heat didn't kick in because he had the temperature up so high. Now the thermostat is in the hallway, (and even with) a sensor in an apartment, we heat the hallway. We're going to try and figure out what to do; maybe put a thermostat in the back. I think we need two systems but I don't know how much that would cost. (#8)

Making changes to condo buildings – especially in historic districts – can be very difficult. Adding anything to the outside of an historic structure – and sometimes to the inside as well – can require approval from city, state and even federal entities. A Boston woman cautions, "The problem is we live in a historic neighborhood. We can't put anything on the outside of the building; it would have to be approved. You can put it on the roof – they're even a little fussy about that, but for heating and cooling it would probably be approved."

> I'm sure there is some type of outside compressor unit that has to be put someplace. We've thought about doing certain things in the past, and we're just really restricted in what we can do. It might be quiet but I'm sure it would be noticeable in some respect. I'd actually have to get approval from the Charlestown Historical Society and I also have to – I'm not kidding you – the people from the National Trust have to take a look at it. We're very restricted on what we can put on the outside of our homes. (#9)

The other issue impeding heating system changes in condo buildings is getting a critical number of owners to agree not only to the change, but also to the expense.

> If we were to replace the heating system, it would be building-wide. I don't know what the support would be for a building-wide change. People would want individual control, but they won't want to pay for it. We would need a special assessment for the building. The reason I would do is because of re-sale value. Let's say it costs $10,000 per unit. Would I get $10,000 more when I go to sell, or would it sell faster? (#8)

> In condos you have a vote. I think for this type of project, you'd have to 66 and two-thirds people to vote yes. It is not as easy as in a home in terms of making that investment. I have no idea if that's a fair price or not. I think it would have to be agreed on if there is a piece of outside equipment that has to be installed. You'd have to get board approval. If it's just equipment that gets plugged into my own unit, I wouldn't have to have board approval. (#13)

> We are heating half of Beacon Street – it drives me nuts! We have the thing jacked up to 74, which is unconscionable, and then we have a really hot hallway in the back and we have people bitching that they're cold. (The environmental component of installing heat pumps) is very appealing and I think it would be appealing to the people in the building. It's the cost and the feasible of it (that is difficult). It drives me nuts that this heat is going, yet I know it's not fair to the people in the back to have them really cold. The comfort level of it appeals to me. This is ridiculous. (#8)

There can be potential legal issues that must be addressed when condo communities make structural or system changes as well. Decisions as simple as where to place equipment and whether to stack it can be fraught with tensions.

> A lot of the roof would be covered with (condensers) I know you can stack them, but that raises all kinds of issues, if they leak. There are so many things with a condo, I like to keep things as separate as possible to keep the gray areas minimal. In a condo, you really have to think, 'What if something goes wrong? How will we deal with it and how will people react?' When you own a house, your rights and responsibilities are pretty clear. When you rent, your rights and responsibilities are pretty clear. When you have a condo or a coop, there are all these gray areas, and you need to get the gray areas as narrow as possible. (#8)

3.2.3 INTRODUCING ASHPS IN NEW ENGLAND

Most Know Very Little About Heat Pumps

It is not unusual to find New Englanders who have never even heard of a heat pump, much less an "Air Source Heat Pump." A younger Boston man remarks, "No, it doesn't ring a bell." A younger Somerville man, who happens to be a commercial architect says, "Don't think so…" when asked about heat pumps and mini-splits. A few wonder if the technology is the same as geothermal heating.

> Is that geothermal? No, never heard of it. (#3)
>
> Air Source Heat Pump? No (I haven't heard of it) but it sounds like it runs off a heat exchange system, with evaporators, like a refrigerator? [Mini-splits?] No haven't heard of that either. (#5)
>
> A heat pump? Is it geothermal? [Mini-split?] No, never heard of it. (#7)
>
> I have not heard of them. (#13)

A few homeowners – usually older or more environmentally-focused – have a little more information or recognize the technology when referred to as a "mini-split," or by manufacturer ("Mitsubishi") or a brand name ("Mr. Slim"). If New England homeowners have heard of heat pumps, it is usually because of a personal connection – a friend or neighbor has one. Their initial perceptions of heat pumps range from "efficient" to "expensive" and "ugly." An older Northampton woman remarks, "I've heard of them but I don't know how they work. Don't know anyone who uses one. Would want to know the upfront cost, are there any rebates, what is the cost of maintenance. I don't know anything about it. How do they compare to an oil furnace?"

> I have heard of them; I'm not quite sure how they work. I've heard that in milder climates – the people I know are in North Carolina – they were talking about this heat exchange where it works fairly well, and it's cheap and very efficient. I really don't know the details. I don't know anyone locally who uses one. I would (consider a heat pump for my home) if I was exploring a new heating system and I was going to upgrade, I would look at it. I would also look at geothermal. But I'm very happy with what I have. For the heat that I get for the money that I spend, I think I'm doing pretty well. I'm not really interested in upgrading my system. (#1)
>
> There is some kind of thing that Mitsubishi puts out that is an air conditioner/heater, but I think it's electrical, which is not great. But I live in like a townhouse and there has to be a place on the roof (for the equipment) for 12 units, so if that gets approval I would it for AC, but I would never do it for heating. I don't want to have electrical heating. I've heard it's really expensive. It may esthetic also – don't they have those ugly baseboards? (#8)
>
> [Mitsubishis are ASHP- sound familiar?] I don't know. They're small, like the size of a suitcase. (#8) [Mini-split?] Yes, I think that's it, but I'm not sure. I might have read that somewhere else. [Mr. Slim?] Yes, yes. I think it is a Mr. Slim. It's that kind of thing. I've seen Mitsubishi advertised since then. Someone proposed getting one, but the board didn't give them permission. They felt if they gave it to one person, they'd have to give it to everyone, but there is not enough room on the roof. There actually is enough room on the roof, but it also required an easement because it wasn't just over common property, if it leaked or anything. It's complicated. (#8)

> They are not a help in a power outage and they can also function as air conditioners. I have a sense they're a good option because they're fairly energy efficient. People I know who have them are pleased with them. About a year ago, there is an informal or a community environmental action team. They were sending around emails asking about some sort of group purchase. (#12)

A few are currently considering heat pump technology for their homes. Interestingly, a few have recently installed heat pumps.[21]

> Yes (I've heard of them). Rather than trying to generate heat with a burner, they essentially move heat from one place to another. A heat exchange kind of thing. I think the Mr. Slim units that I spoke about from next door work on a heat exchange principle but I don't know for sure. We are considering that (technology) for at least cooling, if not heating. I did know they can heat as well, because they can be reversed. I don't know to what extent (the neighbors) use (their heat pump) for heating; I know they have another heating system. (#6)

> I think a heat pump…the older ones got a bad rap. I think mini-split is more appealing, even though a mini-split is a heat pump, yeah. I think that's what the manufacturers decided to do. (#4)

Homeowners Excited By Info About ASHPs

When read a short description of heat pumps and their utility in New England[22], homeowners are intrigued. The prospect of air conditioning is particularly appealing to many Massachusetts residents. A Somerville man recalls, "The fact that they work in colder temperatures now, the fact that they can do AC as well in the summer, as well as being more eco-friendly and less expensive."

> The one thing that stood out was that (ASHPs) are now improved and work better in cold weather. I know they work well in North Carolina where the weather is not as extreme as New England. I'm happy to hear they've improved the technology. If I was looking for something, that would be in the equation. (#1)

> Cost effectiveness, the humidity issue…I have to run a dehumidifier all summer and into the fall in the basement. I run the AC in the living room to help decrease the humidity. If this decreases the humidity, it would help cool off my bedroom. The AC piece is really appealing – oh my gosh, yes! (#2)

> If I wanted air conditioning I would be much more likely to get a heat pump than a traditional air conditioner, because of the energy efficiency, the fact that it doubles as a heat source, and it's smaller and less ugly. I've

[21] Two of 14 respondents have actually installed heat pumps in their homes in the last 24 months. Their reactions and the process that led them to ASHPs is explored in section 3.2.4.

[22] "ASHPs are a viable option for New England homeowners who wish to lower their heating bills and reduce fossil fuel consumption with a more energy-efficient, environmentally-friendly system. While traditional ASHPs have been less effective at very cold temperatures, recent improvements in heat pump technologies have led to the development of new cold-climate ASHPs that can effectively operate at very cold temperatures (e.g. all the way down to -15 degrees F), while saving homeowners hundreds of dollars or more a year if they heat with oil, propane or electricity. In addition, heat pumps provide air conditioning and dehumidification in the summer, and are much quieter and more efficient to run than window AC units."

> looked at a neighbor's once, but haven't really spent time in a room with one in operation, at least that I know of. (#12)

> Sounds like you could save energy, but again, I'd need to do research on it. (#13)

Quite a few homeowners ask for more information about the technology. An older Northampton man queries, "How do they work? I know there is some sort of air exchange, where it takes the cold air and heats it before it comes in the house. They say there is heat even in the cold air. I never understood basically how they work." A younger Providence man comments, "I hear the language "air source" and I'm wondering, 'what is this thing doing?' I'm curious about the functionality of it, how does it work. If I was looking at a brochure or website, I would looking for a diagram or schematic that tells me how the technology works. I need to understand it from that perspective so I understand how I could integrate it into my house. I want to see the 'prove it' information before I get excited about how easy it is to integrate. I need to be sold more on what it is and why it's so much more efficient."

> I'd want to get more information. It sounds good, but based on the description you gave me it works better and would save me money. I'm an analytical kind of guy and I'd want to know about the technology being used and the details around the cost savings. I'm also a homeowner that doesn't have a lot of surplus income, so my first set of questions would be about the cost – to install it, the demonstrable cost savings. Then my second line of questions would be about the technology itself. I'd like to understand what I'm dealing with, examples maybe from other areas of the country that have demonstrated the performance over the long haul. I'd like to understand the environmental impact, but as much as I like to be an environmentalist, I can definitely tell you that my order of progression of considerations would be: first, cost; second is durability and longevity, and third is environmental impact. (#7)

New Englanders also have questions about cost and reliability. A Northampton women asks, "What issues might I have with this new system – will it work for me? Because my furnace has been trouble free." A Boston woman wonders, "How much energy do you save? How much does the installation cost – is it worth it to install? I'm certainly for saving energy but I really have to know more about it."

> (This) sounds really good, especially the fact that it would be reliable. Initially you said the new modern ones work in cold weather. That was a concern, but I don't know how long ago it was developed. How new is it? I don't want a device that is within 2-3 years. I want something that is tried and tested over many years, 5-10 years. I would want to know customer satisfaction, maybe consumer reports or something to verify how good this is. I would not go by one company's word, to be satisfied that I would be making a good decision. (#2)

> Looks good, but I don't know how it works. I'd have to investigate it. You (say) it works even (in cold temperatures). How much does it cost to install it? If it's too expensive and takes too long to get the money back from my investment, I don't think I'd do it; I don't know how long I'm going to live in my current house. It all depends on the installation cost and how much money I can save. It might be worth it if I could get my investment back in 5-10 years. (#3)

> Is there a separate industry around this, or would they be available through some appliance store? Where does one go to find out more? I'm guessing the power source would be electric. If it's more efficient, my question would be cost. (#6)

Many have questions specifically about the installation because they have never seen the technology before. A Northampton woman asks, "Do I need ductwork? The expense of the unit – how much would the unit cost for a small, one story house? Is this all electric?" An older Somerville man also wonders about what changes might be needed for installation, "Another question I might have is the requirement for ducting and how it's delivered within the house." A younger Providence man adds, "It does both heating and air conditioning and it sounds like it's more efficient. I've never heard about it, so I don't know what the initial cost is of having it installed. It sounds interesting, because it does both heating and cooling. What space requirements are there? What additional apparatus needs to be installed? I would look at that, look it up online."

> In a condo building, where is the system located – is it in the boiler room or on the roof – and how does it get to each unit? How would it be set up in the units? It is certainly something to think about it. I'd have to read and study more about it. Nothing stands out for me without reading more about it. (#13)

> The question I would have, is what unit do you have – is it outside or inside? How is it connected to a central vent system? (#1)

Giving homeowners just a bit more basic background information[23] about the technology is helpful for those who have zero exposure to heat pumps. Explaining that the power source is electric and that heat pumps work like refrigerators to transfer heat in and out of buildings are key points of knowledge for initial outreach. This information raises other questions for New England homeowners – especially about the cost of electricity – but it helps them trust that the technology could meet their needs. An older Boston woman asserts, "I think electricity is very expensive in New England, if I'm not mistaken. My bill has really gone up." A younger Somerville man remarks, "Energy efficiency, cost, ease of operation…you have me thinking I wish you called a year ago before I replaced that wall air conditioning unit…I would have certainly considered (an ASHP)."

> I do some cost-benefit analysis, and I'm sure it has some energy star ratings or something, but typically electric heat for the Northeast is prohibitive. It's just not worth it. That's why pretty much everyone is either natural gas or they still burn a lot of oil up here. I'd have to look into it. (#9)

> That thing on the roof is a compressor, right? How does it run? Is it electricity that powers it? Do you have to have baseboard heaters with it? Does go through the radiator? How does the heat get where it is going?

[23] "Air Source Heat Pumps transfer heat in and out of buildings. In the winter, they pull heat from the outdoor air to provide efficient heating and run in the reverse in the summer to provide air conditioning. ASHPs use vapor compression like a refrigerator and operate on electric power."

With this system installed, we wouldn't need the boiler? How much does this cost to run? How much does this cost to install? (#8)

A cleaner source of energy, saving money, quiet is good. The two I've seen don't look great; they just look like big boxy things in the wall. I wish they looked a little bit neater or less noticeable. I know they save money, but you gotta lay some money down first. I wonder what kind of rebates are out there for things like that. In time, I do think I would consider a heat pump, but we just bought this house two years ago. It was a big upgrade from our first home, so we kinda maxed ourselves out with this home and we've got a one year old and a three year old in daycare, so you can understand where we're at financially. The burner we have is really efficient. I think if I just took some better steps to put some weather-stripping on the windows, that would get me through. But if I were to get something else, I think a heat pump would be the next option. I don't see that happening in the next few years. I have to wait until at least one kid gets out of daycare. (#10)

That's great. Technology is always changing. I'd have to investigate more to see if hypothetically it would be something I'd use in my brownstone. It's in the city, so there are limited things I can do inside because of the nature of the historic home, but also there is a covenant of what I can do on the outside as well because the house is on the registry of National Historic Homes. So if there are compressors that need to be put out, if there are other things like ductwork I'd have to look at it. (#9)

Answering Questions About Installation

The versatility of heat pump installation is a strong selling point for New England homeowners.[24] Many do not have a duct system in their home, and when they learn they can take advantage of heat pump technology without it, they are impressed. A younger Providence man muses, "Sounds like there is more than one way to do it. Having more than one option is good; you don't have to say, this is where it's going to go and how it's going to be done."

...it could be individually tailored to my needs. I'm wondering about the cost, to me there is an obvious need for big spaces, like the bedroom and the living room. Would this heat my bathroom and kitchen as well? I'm wondering how much would it cost to heat my house. (#2)

Their controllers seem to work effectively and as easy as a TV remote. I think they could be hooked up to your phone app fairly easily, so it's not surprising that (a wireless thermostat could be used with these). (#6)

I do have heating ductwork through my house and a furnace in my basement, so I'm confused. I hear that it integrates within my existing network, but I'm confused at how many parts there are distributed throughout the house and I'm curious how that works. Do these units use electric power? And they can go in a room, or through the ducts? [Given more info] Now that I understand, I don't think it would work in my house. I have radiators, and I was probably thinking that 'ducts' could be interchangeable with 'pipes.' Now I understand

[24] "There are a lot of different ways in which a heat pump could be installed in your home. No ducts are needed. One or two indoor units could be installed in specific places in your home – like the living room or master bedroom – to provide extra heating and cooling to the room. Alternatively, you could install three or more units (or a central system that uses your existing ductwork) to heat most of the home. All of these systems could be remote controlled with a wireless smart thermostat and link up to your existing system to maximize efficiency and home comfort."

> that this would not be physically connected to my heating system in the house. [When I heard how it is customizable]…I'm starting to understand a little more…it's almost like it's a space heater with new technology. (#7)

Alternatively, some homeowners with ducts in their houses are interested to hear that heat pumps can be installed that way as well. A younger Portland woman remarks, "I've seen them installed where they are on an exterior wall. I did not know they could be used other than on the wall. I didn't know you could duct them." There is still some confusion for owners to imagine the technology without diagrams and pictures. The visuals will be extremely important to convince New Englanders to incorporate heat pumps into their systems.

> It sounds really interesting. Where do I buy something like this? What's the cost? As an architect, I know a little bit about it, I would want to see installation diagrams, the parts and how they go together. (#14)

Esthetics Can Be a Hurdle

For some New England homeowners, the idea of a heat pump mounted on the wall of their living room is unappealing. The esthetics of the technology can be a hurdle for some people. However, for most, this issue is not a deal-breaker. A younger Providence man asserts, "What if you don't like the look of it? You have a hole in your wall. If you could use your ducts, I would like that – that would be better."

> That would hinder me…I don't like a lot of stuff on the wall. I'm pretty particular about changing the inside of the house and the appearance. I'm the same way about the outside. That's part of the reason I installed central air conditioning; I don't like AC units hanging out of the window. I had one built into the wall and I never liked that either. I don't like how it affects the appearance of the house. Now if the cost of oil went up so much and I was spending $1000 a month instead of $100, then I would make some compromises about how the house looks. It would have to be significant for me to make that compromise. I don't live in a historic house where I couldn't make any changes to the outside. (#1)

> Um, they're a little bit ugly. They're certainly not beautiful. They're terribly offensive if you have a place to put them where they are out of the way, but that's part of the reason why I don't want one. The place we would have to put it, it would be a big white box on the wall in an otherwise attractive space. (#12)

> (I've seen my neighbor's heat pumps). I think they're fine; they're unobtrusive. They don't take that much space; they're not necessarily ugly. I don't have a strong view of esthetics, so it doesn't bother me. The insulated pipes that run from the unit to the condenser would be my most significant esthetic concern but as long as they are painted the house color, they tend to blend in over time. (#6)

> I can't tell you about the esthetics of it unless I saw a picture of it. I don't have a great sense of what it looks like. Does it look like one of those mechanical boxes you see on top of buildings, and it's just sort of popping off the side of the building? Is it paintable – can I paint it to match the color of my house? (#9)

Heat Pump Costs Deemed Reasonable, but Investment Still Daunting

New England homeowners are reassured about heat pump technology when they see that installation costs are not much more than an oil or gas furnace and AC system.[25] An older Somerville man says, "(The costs) don't seem unreasonable." A Boston woman agrees, "That seems reasonable. It is certainly an investment if you're talking about $4-8000 a unit." In addition to the initial outlay, homeowners want to know about monthly costs – and cost savings. A younger Providence man asks, "What is the monthly cost – how much money can I save per month? Green energy is not for everyone. Most people don't care about green energy – they care more about the money."

> Those numbers don't seem outrageous. It's not completely out of hand. I also want to hear what the monthly cost savings are. All I know is that this heat pump is supplemental to my other heating, so let's say it does everything outside of January and February. Which is great but I would then need to see the amount of money that this saves me and I would need to understand what it's going to do to my electric bill. The bulk cost doesn't mean much by itself. (#7)

> What are the monthly costs to heat my house? How does that compare to oil heat? That would be the issue. Why get this if it costs the same as oil heat? I'm looking at the value comparing the cost of my expense over the year of the cost of oil versus the electricity. I would want a significant savings to cope with the upfront expense. (#2)

Homeowners expect that it will take time to recoup any initial investment of a heating system. An older Somerville man insists, "Installing any kind of heating system incurs costs. That's the cost of hardware." Some have similar experience with solar or pellet stove investments.

> I can see the long-term benefits. I work in commercial buildings and it is very difficult to get people to see the long-term benefits that might offset some upfront costs, which is a frustration. I'm also very excited about renewable energy and alternative sources and as I look toward home ownership after the condo, I can see possibly having a solar system to run (a heat pump). We're certainly on board with upfront costs being offset by long-term savings. (#14)

> Initial costs being higher but you save money over the long term. That's kind of like what I did with the pellet stove. Initially it was a big outlay but we saved so much in the first two years that it paid for itself and ever since then, we've saved quite a bit over the last five years using mostly the pellet stove for heat. Being able to do something that is more efficient and saves you energy costs, that's interesting. (#5)

> I installed solar panels…you have the upfront costs and then you amortize it. So I understand that heat pumps could cost a lot (up front) and you'd save over the years. I like the rebates. I received rebates and federal income tax credits. I understand how energy incentives work. (#1)

[25] "An ASHP system that serves most of your heating and cooling needs costs about $12,000-$13,000 to install, a system that covers 50% of heating/cooling needs is $4-8000, compared to $4-6000 for a boiler/furnace and another $5-7000 for a central AC system."

However, many still consider the outlay difficult or not cost effective. A younger Portland man maintains, "[$4-8000 for a partial system]…that is out of reach at this point in my life." An older Northampton woman agrees, "I live alone; I would not want to air condition the whole house anyway. Expense is a big factor to me; I just retired and so my income has decreased substantially. I wouldn't be able to afford a large expense or a large debt." Owners generally do not consider adding heat pump technology to their system for environmental or cost-saving reasons alone. Only if they need replacement equipment – or want to add air conditioning – do heat pumps really appeal.

> I think the systems I have are so efficient that I don't spend enough to see a big payback. If I was having a problem with my boiler and needed to replace it, I would look at all types of alternatives. I understand how the incentives work, but I don't see it being cost effective for me. (#1)

> I don't know if I would be able to afford it, especially since it would be more expensive than a traditional furnace. I'm hoping the cost would go down to accommodate a smaller house. I'm still wondering if the bathroom would be heated. How do you tailor the heat pumps to the house? (#2)

> If you were replacing your system, it sounds like the cost is almost the same. My system can run for another 20 years. Even though it could save a lot of money with increased efficiency, but I probably won't save enough to upgrade to a new system. (#3)

Rebates More Desirable Than Low Financing

Financial incentives help homeowners to consider heat pump technology for their homes.[26] A younger Portland man asserts, "No doubt about it – I would look into the rebates. 100 percent." A younger Portland woman adds, "I think I was aware that there were some rebate programs; that's why people I know were doing (installing heat pumps). Most homeowners prefer rebates to low financing. An older Somerville man wonders, "Is Massachusetts one of the states you can get (incentives)? I'd rather a rebate to a loan. We try to avoid loans." They ask about the details – they want to know how much of the installation cost the rebates will cover. A Northampton woman asks, "(Do the) rebates offset the cost? I need to know numbers…So $12,000 for heating and cooling? And the federal credits? Does that depend on your income?"

> The expense would be a key issue, so the rebate would be better. Maybe 15% would make it appealing. I would take advantage of the 0% financing. I'm struggling financially. (#2)

> (The rebates/financing) make it more interesting because you don't have to have the initial cash outlay if you don't want to. That would not be a major consideration for me; I could buy it at once if I had to. I would just want to know all the numbers before I made a decision. (#5)

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[26] "As a high-efficiency renewable heating and cooling technology, ASHPs are incentivized by many state agencies and utility programs through partial rebates, special financing (some states have zero percent interest) and other low-interest loans. However, ASHPs do cost more than traditional fossil fuel technologies to install. While homeowners will see sufficient energy savings to offset this cost, it can take several years to cover the additional cost."

When you tell me there are state programs, I am more interested but I want to understand the specific (rebates). I'm a planner, I'm someone who works for local government and I do know what the state offices are, but I'm still not likely to make the phone call on my own. It still seems like a long shot that it's going to make sense for me from a bottom line perspective. When you say rebate, do you mean a hard cost reduction? Definitely that (is more appealing). I'm in a position where I have a mortgage and a number of other loans out there. Taking on another loan right now, whether it was no interest or low interest is not as attractive to me as telling me you'll be able to negotiate a 30% off – that's what would work for me. (#7)

That certainly sweetens the deal. I have to say I was very disappointed a few years ago when I bought my condo and made a lot of improvements. I wanted to replace the thermostats because they are very old and I wanted something programmable to take the place of me having to adjust them all the time. There are four of them in this electric baseboard system. There was a rebate that was a considerable amount of money but electric heat was not eligible! I was so disappointed and ended up taking them back and not replacing the thermostats. Anything that's supported by rebates I'm absolutely for it, especially if it encourages people to do something a little better. (#14)

The incentives may (push me towards a heat pump); it depends how high (the price of) oil went. I remember a couple years ago, it went up to about $4 a gallon; now it's about $2.50 a gallon. That's when I bought the pellet stove. If the price went up and was approaching $5 or $6 a gallon, I'd say I'd have to make another move, because that would be a lot of money. It would have to be quite a dramatic increase. (#1)

How much is the rebate? It would be important if I were in the market for a new system. For homeowners like me, it would not be a good investment. I think when your system is 15-20 years old – that's when you start to think about it replacing it. (#3)

Cost Comparison Matters to Homeowners with Access to Natural Gas

For homeowners with access to natural gas, learning that heat pump technology cannot compete on cost[27] takes heat pumps out of the equation. This is especially damning if the home already has installed air conditioning or the homeowner really does not want or need AC. A younger Providence man warns, "That's not good for an investor like me. Energy-wise it is very efficient, but cost-wise, it's not that efficient. It will take a longer time for an investment to return. That would keep me from looking at a heat pump." Another Providence man agrees, "With this information, I put this in the category of something I probably will not consider. It's good for me to be aware of; I want to understand it. Maybe five years from now, the technology will evolve."

That totally doesn't sell me on it. For me, the first consideration is cost. What is the upfront investment versus the cost savings over time. This sounds like it is not cost competitive from that perspective, though it is a very environmental choice. While I'd like to make a wise environmental choice – I work as an urban planner in a

[27] "While ASHPs are very efficient, they provide the highest energy savings to homeowners already heating with electricity, then to homeowners heating with oil and propane. They are not cost-competitive against the current low prices for natural gas. You do get a more environmentally-friendly system, plus added higher-efficiency air conditioning in summer, and a hedge against a future rise in fossil fuel prices, but it could take a while for homeowners to recover their investment in the current economic environment."

realm where I try to promote sustainability and better growth practices – I'm at a point in my life where the bottom line is the most important thing. (#7)

It's gonna be a tough sell. Power plants do burn coal, and while they're trying to ratchet down what is acceptable to burn…it's going to be a little bit difficult in the Northeast because people like burning oil. That oil business is not going to go away. The way things are set up in most homes and businesses, if it's not oil, it's natural gas. The big companies set their commodities contracts months in advance and if they hit it right, it can be pretty inexpensive. And natural gas for the most part, is clean. Especially with all the fracking that's been going on, there is going to be even more. So if it's clean and it's cheap, why have this other capital outlay of this heat pump thing? (#9)

It's using electricity to actually run the system. Electricity has gone up most of the time. I don't remember a time it has ever gone down. They are not really creating a lot more electrical power plants around here, so the cost of electricity is probably going to go up.

Homeowners who do not have access to natural gas, are more environmentally-focused, or concerned about fossil fuel price volatility still want to give heat pump technology a chance. An older Somerville man observes, "All things being equal, being ecologically friendly is a reason to prefer it over something oil-dependent."

That would be a tough choice to make – between a less expensive gas system to a more expensive heat pump. At the same time, the rising cost of fossil fuels is always a concern. We will probably buy a fixer-upper, and chances are that could include a new heating system. We have our ideals and what we believe about the environment, energy efficiency and sustainability, but I could see it being a tough choice if we have a cheaper, less efficient system. I remember in 2005 I moved out of a place that had oil heat and was very thankful for that when a few years later the cost of oil went so high. I got in and out without too much damage to my pocketbook. (#14)

I'm surprised it's not competitive with natural gas. I'm not quite sure how much cheaper natural gas is than oil right now. Is it 50% savings now? I haven't looked into it because I don't have that alternative available. (#1)

Reactions to Using Multiple Heating Systems

For some homeowners, needing to install a heat pump as part of a multi-source heating system[28] is undesirable. If they do not need air conditioning, many do not understand why they would want to use a heat pump and another heating source. An older Northampton woman explains, I don't think that is something that would interest me. My primary need is not increasing my air conditioning. I'd be more

[28] "Heat pumps are usually installed as an additional heating source, instead of completely replacing a heating system. Homeowners who manage both the heat pump and a pre-existing heat system with proper thermostat control are most effective at reducing their energy costs when their heat pump acts as the primary heating system at the right time. With the exception of very well-insulated homes, ASHPs cannot serve as your only home heating source, though you could use your existing system or install backup electric heating to keep you warm on the coldest days of winter."

interested in a unit that would replace my furnace. I don't think I would go to the expense to get it as supplemental; I'd rather buy it to replace the furnace."

> That's a little surprising because it was described before as a cold climate option down to -15 F. I don't recall it getting much colder than that here, but it would seem unfortunate to have to have another backup unit to support it. Our oil system is on all the time; it also supports the water heater. The previous burner we had, if you turned it off in the summertime, it would rust or corrode and you'd have to clean it. We were told to keep this on year-around, even though it's not be used for heating. There is a thermostat could be set lower, but not so low that the unit wouldn't go on. That could be a problem for me. (#6)

> Seems like a newer technology, so maybe more people in the suburbs have it. The people that I know, I don't ever remember everyone talking about having one, or supplementing their heating system with one. (#9)

Other New Englanders are already utilizing multi-source heating systems, whether for cost savings, comfort, convenience or emergency backup. An older Portland woman says, "My neighbors have a pellet stove; they installed a heat pump because they were tired of going down to the basement to get pellets. Dealing with the big bags (is a pain)." A younger Providence man comments, "(Using multiple systems) sounds like how I think now; that would not change how I think. I would not be deterred by that." The use of a supplemental system does not phase them and even sounds appealing. Another Providence man remarks, "When you were first describing what a heat pump was, I wasn't sure if this was something that goes in my basement, or if I hook it up to my existing system. Now I'm envisioning more of a new kind of space heater with an electric power source."

> That's pretty much what my understanding was about heat pumps – that's it's so cold you need some sort of back-up system or auxiliary system. (#1)

> It is a good idea to use as a supplemental heating and cooling system, if you can save money. That sounds like a good idea for the room that I spend the most time in. (#3)

> I'm getting the sense it's designed to heat and cool and it can get me to a certain temperature threshold but after that, my main heating system needs to take over. So if it's a 50 degree or 40 degree day this could help get my house to whatever desired temperature I want, maybe 65, but on a zero degree day, I would need another system to do the heavy lifting. (#7)

> How would it work (in our condo building) where one side is just intrinsically warmer than the other side? In another building I lived in, it would get so hot that in the dead of winter, I'd have my windows open. This (ASHP) is actually intriguing. (#8)

> It does make sense (to have multiple systems) for different zones in the house. My air conditioner is in the living room, it does manage to get the bedroom, the bathroom sort of, but it could certainly be better. With the setup you're describing, I can understand clearly how the heat pump would serve as the main unit for the main room, and then if needed I would use the less efficient supplemental sources for the other rooms. I can imagine the (heat pump) being more efficient as the primary. This is information I will take with me (for

my next home). My girlfriend has gas heat and no AC. I have trouble sleeping when it gets too hot. And in the winter there are definitely cold spots. (#14)

I think having approximately the same costs for one thing that does both (heating and cooling) – that could be really good. If it breaks, that could be a problem. I sometimes like having more than one system, if one goes down. For instance, if we lose power, our furnace doesn't run. The pump won't work without electricity. So with the pellet stove, I can run that on a small generator and that's an easy fix. We also have the option, we could heat with the natural gas that's already in the house. I like options; sometimes things don't work properly and you need to have more than one way to get there. (#5)

I don't have the most insulated home with tons of windows. It would have to be a supplemental for me. I think one friend uses it a little more as a primary than the other (friend) does. They are both really smart people; I would think they got educated in how best to use them. (#10)

ASHP Maintenance in Cold/Blizzard Conditions

For a few New Englanders, having to clear their heat pump during a blizzard is problematic for the technology.[29] An older Northampton man asserts, "That certainly is a big disadvantage! I wasn't aware you have to clear the snow off it, especially during a blizzard. I would not enjoy having to go out and clear snow during a blizzard. That's for the birds!"

That's not gonna fly around where I come from. This was a relatively mild winter but (normally) there is too much snow. You go and dig out, but no one's going to want dig out more than their driveway, the primary things. Why are you going to want a system that a) you're going to have to dig out and b) is not really going to do too much for you in the real cold temperatures. Not a selling point. I see that as a problem. (#9)

That would be a problem for me because shoveling snow is a problem. I do as little shoveling as possible. This heat pump would probably mean I would have to traipse around the house to shovel. That would be a deal breaker for me. It gets very cold here in Massachusetts and the idea that it would not be efficient on those days…we also get a foot or foot and a half of snow sometimes. This means the heat pump would not be heating the house very well. (#2)

How often do I have to clean it? In New England, the snow can be quite high. Three years ago we had snow almost six feet high for 2-3 months. I don't know what you'd do with a heat pump in that. (#3)

Other hardy New Englanders are less concerned. A younger Portland woman says, "I didn't really know that much detail about it. Seems reasonable." They do not necessarily relish an additional task during a storm, but are not ruling out heat pumps as a result. A younger Providence man comments, "We live in

[29] "New technology has made Air Source Heat Pumps more efficient than ever, but heat pumps still extract heat from the outside air, so on the coldest days of the year, the system is least efficient. This means that most homes require a backup system to keep the home sufficiently warm. ASHPs also have outdoor components exposed to the elements. While properly installed systems are mounted more than a foot above the ground and covered, and small amounts of snow won't interfere with operation, the unit should not be buried in snow, so keeping performance high during a blizzard may require homeowners to clear it."

New England, we get some deep snows. This would be one more thing to shovel or clear in the middle of a snowstorm. I don't love it, but since the height of it is variable, I'm not going to be worried about it too much."

> If I was depending on it for my primary source of heat then that would be a problem, but during a blizzard I probably wouldn't worry about it unless it was going to be a catastrophic failure. I have (another system) so I would just wait until it wasn't dangerous outside. (#5)

> That's a concern, but not a surprise. I still do a lot of snow blowing and shoveling in the wintertime. It would depend where it was and how easy it would be to clear it. The unit is on the ground; I don't think it is more than a foot off the ground. Maybe that explains why they don't use it for heat, or why it's not a concern. (#6)

> That sounds like common sense. They always say if you have any kind of appliance like a pellet stove or anything that has an exhaust, you gotta make sure the snow doesn't back up into it so you don't get monoxide poisoning. Pretty much common sense. My friends have them installed up high, just a couple of inches from the ceiling. It's long and rectangular. (#10)

> I don't see that as being a problem. There are things you could to do to make it easier to maintain. If I know that's a factor in the functionality of the system, I have no problem shoveling and doing what I have to do. (#14)

Environment is Bonus, Not Driving Factor for Most Homeowners

Making an environmentally-friendly choice with a heat pump[30] is extremely attractive to many homeowners. An older Somerville man says, "That's a good thing. A significant reason to look into it." A younger Somerville man agrees, "It sounds fantastic. We would consider powering an electrical heating system through solar means for the exact reason you're talking about."

> They sound more energy efficient, less carbon, which is a pollutant, and if you can reduce that by any means, perfect. I'm glad. (#9)

However, most do not put the environment above cost. A younger Providence man asserts, "Frankly speaking, the environment is very important, but I care more about the money. That is my feeling, but I think a lot of people think the same way. I would rank my concerns – first installation fee, monthly cost, time of investment return and then environment." A Portland man adds, "I love (the environmental) aspect of (heat pumps). I'm a huge advocate for the environment; I'm just stuck with what I've got right now. If I had the money, it would already be installed. It's the upfront money (that keeps me from doing it). They're just so new that the price just hasn't come down far enough to jump on board."

[30] "Heat pumps are efficient, reliable, and environmentally-friendly. Installing an ASHP can help you reduce your carbon footprint from heating (and cooling – if they have it) by as much as 60 percent. And if you're powering it with solar or other renewable electricity, it's virtually carbon-free heating."

Sounds good. I think I am environmentally conscious, energy saving and very careful with resources. The environmental aspect (ranks) very high for me. When I was installing the solar panels – you go through a similar type process – and there is always this rating system. Why are you doing it? Is it environmental, financial, some feel-good type things? For me, I'm very concerned with the environment, but I'm also concerned with the financial side. I never know which to rank higher. If something is great for the environment but is costing me a lot of money, I'd say I'm not that hot on it. If it's cheap and saves me money and is good for the environment, then it's a home run. (#1)

Thinking about how much carbon we put in the air already, I'd like to see a way to reduce that. Right now, we're either burning fossil fuels or tree matter to heat the house, both put carbon into the air. I'd like to see if I could avoid it, if it were less expensive for me. I would look at it. (#5)

That statement is (persuasive because) you were able to include a statistic. Up to 60 percent makes me feel very good about it. I'm sure it's variable and depends on the source of electricity because oftentimes electricity is coming from a fossil fuel in the first place. That statement gave me an impetus to look into it, even if (the environment) is my third (importance) factor. It intrigued me. I need the background information and statistics first, then you can sell me on why this is such a great thing to do. (#7)

I think that's great and if it saves money, it's something my building should consider. I would like to see the material in writing and look it over before I would recommend it to my building. (#13)

That's good. I try to be conscious of my use of resources and our country's overuse of resources. This is one of the biggest uses of resources, and it's one where it seems pretty easy and cost-effective to do the right thing. To me, there's no sacrifice. I can have a cheaper, more effective, environmentally friendly system, so why wouldn't I? It's not like doing the right thing means I have to be colder or spend more money. (#12)

Solar Knowledge Correlates with Interest in ASHP Technology

The process of investigating and considering solar technology has significant parallels with Air Source Heat Pump technology, especially in New England. Not surprisingly, homeowners who either have solar or seriously contemplated installing solar tend to be more interested in ASHP technology – including both respondents who recently added a heat pump to their home. Being able to run a heat pump with solar energy is obviously a huge advantage. A Northampton woman explains, "I have solar panels. The use of electricity is not an issue for me. It sounds good. I'm interested." There are also similar barriers to the two technologies, including initial upfront cost, availability of incentives and questions about long-term payback. A younger Providence man remarks, "We have looked at solar, but right now I don't use enough electricity to even make it worth looking at solar. My power bill is less than $100 a month even at the height of my use. I found it wasn't going to be enough of a savings in the long run to make it worthwhile." Several suggest a program like 'Solarize' for heat pumps. An older Northampton man insists, "I would look at it; someone looks at all your bills, your insulation. They explain how it works, what the expense is, how long it takes to pay for it. If it were gonna work, I would consider it. Right now, I don't think I'm a good candidate."

With the solar, I was thinking about it for a number of years. I had someone come and explain it to me. The reason I finally did it was that the State of Massachusetts has a lot of incentives to make energy improvements.

They had Solarize Northampton. The state targets several communities each year and the companies come in and they try to get at least 100 people to make an economy of scale. Someone else is doing all the research on the companies and on the savings. If they get over 100 people, the cost goes down. It's better than expected. (#1)

Have you heard of the Solarize program? The product you're describing is trying to be environmentally friendly and use electricity…it really jumps out to this is a great fit for anyone that got a large scale solar system that provides the majority of the house's electricity. This is a great dovetail for solar programs – for anyone that has a solar system that already exists, was recently installed or is looking at it – this option should pop up when anyone is researching that. (#7)

There was a lot of information around solar. We were tapped to become one of the solar communities in the state. You can have solar installed and not spend a dime. The company that does the installation sells the extra power to a grid. They make money and you don't pay. You could have a $15-20,000 solar array that doesn't cost you a dime out of pocket. Electricity does have a carbon footprint. I don't have solar. I did consider it, but I'm not in good situation in terms of sunlight, unless they chop down a couple of beautiful old maples in the front yard. I had the people out here, but the second they saw that tree, they knew it was not possible. I could have done a solar array on the lawn, but I didn't want to do that. (#4)

Several people have solar in our area. I thought about it, but we're in the woods. We don't get a whole lot of sunshine. I've never taken the step to ask someone if we get enough sun for solar to be efficient or not. I suspect not, because if we did, I'd grow bigger tomatoes. But there is solar on quite a few people's houses around here. (#11)

We looked into solar and we evidently have a roof that is sufficiently south facing (but) you have to replace your roof after so many years; I'm concerned about damaging (it). I also don't have a lot of confidence in the ability of solar to generate power. I may be out of date in that…it's been a long time since I actually looked into it. (#6)

I suppose we could put solar up on the roof. (We can put it up) if it's not a sight-line. If you can't see it from the street, you can put a lot up there. I think the solar panels would be doable. (#8)

3.2.4 RECENT ASHP INSTALLATION AND EXPERIENCE

Of the fourteen New Englanders interviewed, two had actually added heat pumps to their heating system in the last 24 months. One is an older Northampton man (#4) with a primary oil heat system, and the other is an older Portland woman (#11) with a propane system she no longer uses for heat.

NORTHAMPTON MAN:

Air Conditioning and Lack of Natural Gas Access Drove ASHP Addition

I just added AC last year. It's just one unit and it's a mini-split. I've also used it for heating during transitional seasons when I don't have the heat on. It's a terrific little system. My house is an open-plan so it's in the living room, which extends to the kitchen and dining. It's the first level of the house, which is a tri-level. I couldn't

get central because I don't have forced hot air. You can't redo the house and put in vents everywhere. I'd heard about these mini-splits; the new ones are tremendously efficient, it's like a modern heat pump, if you will. That's what it is basically. There is a unit outside and a unit inside. The efficiency appealed to me. I've never been a big fan of air conditioning, but those dog day Augusts get pretty bad. I'm glad I did it. (#4)

I do not have a natural gas line – I would have immediately put in a natural gas burner. More efficient, less expensive, it burns much cleaner than oil…it's a no brainer, but not available. (#4)

Awareness of ASHP Through Friends, Mass Save, Dealer & Internet Research

I learned about (the mini-split) because I have friends that have them. I had always marveled at their efficiency, how quickly they could heat or cool a space. I did a little exploration on my own and I found they were a good thing. Also the utility company helps underwrite this Mass Save thing – it's one of the things they recommended. You just google "mini-split" and the information comes up. I got a Mitsubishi, which is probably the most well-known of the mini-splits although many firms make them now. (#4)

I decided I wanted to get (a mini-split) and shopped around; got three bids. My regular oil supplier had pissed me off so I didn't go with their bid (but) I think (the oil dealer) is a good source of information. I also googled mini-split, I went to the manufacturer website. (#4)

Raves About Cooling Performance

It's about three and half, maybe four feet long, it's about 6-8 inches deep, about a foot high, it's white, very modern looking. It's adjustable, including how it blows the hot or cool air back and forth or up and down. It's mounted about 3-4 inches below the ceiling. It's quite a well-designed unit, and by the way, extremely silent. It's probably a little louder than the fridge because you have a fan, but it's real quiet. And you can adjust the speed. You don't have to have it blowing very hard, unless you're coming in and the house has been closed up for several hours and it's one of those August dog days. Last summer was the first summer I had it, and I think I only used it 2-3 times because the summer wasn't really crazy. It can quickly cool off a very large space – 10-15 minutes at most. (#4)

The other factor was the cooling capability – comfort. I am not terribly bothered by hot weather, but I live in a valley and it gets pretty darn hot and sticky here. I also have a pool out back – that keeps you cool. (#4)

Could Use Technology More or Better

This house is a tri-level, so the bedrooms are six steps up. When I use the mini-split in air conditioning mode, I would close the doors to the bedrooms and bath upstairs. I installed an overhead fan in the master bedroom and that takes care of business. I probably would not (install a mini-split in the bedroom); I don't feel it's necessary. If (the heat) affects me more as I get older, I might consider it, but for right now, the ceiling fan really does the job. (In the winter) I use a space heater in the upstairs bath. (#4)

I was looking mainly for AC. One of my friends who got this – he has a house without central heat. He uses a mini-split as the primary source of heat and it is amazing how quickly it will heat up the space. It is a relatively small space, but it works. (#4)

If you think about late October, before the heating season – you don't have your oil burner cranked up – it's off. But it's a nippy morning or early evening. You turn on the mini-split, get a little heat and it takes the edge off. It's terrific. (#4)

[When asked if he uses the mini-split with his oil heating:] Very occasionally. I keep the house 66 to 68 degrees. There are some days, really cold with the wind blowing, that I could turn up the oil burner. It might be smarter – I really don't know, it's hard to determine – on that kind of day, I might turn the mini-split on, just to take the edge off. I might leave it going for 15-20 minutes. (#4)

[Anyone ever talk to you about the optimal way of using them together?]: Nope. I think the thoughts would be if you have an oil burner to use the mini-split like I do which is rarely would you use them in combination, but when you have your heating system down, coming out of the summer, even in September you can get a cool day. (#4)

[What would you think about using them in combination so you wouldn't have to rely on the oil burner as much?] It's very possible. I'm not sure about the validity of cost there. I know the mini-split is very efficient but electricity is expensive. Oil is cheaper than it has been. That might have made more sense a few years ago when home heating oil was $3+ a gallon, that turning the heat down to 64 or 65 degrees and using (the mini-split) would probably be a good situation. No one has told me 'mini-split alone would be more efficient,' but it's possible. (#4)

Knowledge of the Technology and Process

(Mini-splits) have a great reliability record. So far, I haven't had any problems. I don't know how long they are supposed to last, but I would say you could easily get 20 years out of them. No issues (with snow), even though there is this big unit outside. We just had a huge snow here last week – 22 inches – and no effect. The snow sits on (the unit); it's not covered. (#4)

The installation process was about half a day. Wasn't much of a hassle. No problem making a hole a wall. These installers have done hundreds of units. (#4)

You can do mini-split central, but you need to have vents in place, controlled by a larger condenser outside. (#4)

Effect of Incentives

We have a program called Mass Save, you can apply for funds to help offset the costs of energy saving appliances. The mini-split was like $3500 and I think I got like $1200. The furnace was like $6000 or $6500 and I believe I got a couple thousand bucks. Mass Save is pretty well advertised. The utility sends out notices with the bills. There's a mailing list if you've ever applied. They do a home energy assessment and when that's completed, you're then eligible to apply for funds to underwrite the cost of new energy efficient equipment. Most companies you work with will assist with the Mass Save paperwork. (#4)

Mass Save recently added mini-splits to the list of things you can get. Mass Save is funded by the utility. It's a cooperative arrangement between the state and the utilities. The Mass Save program is kind of similar (for heat pumps). It throws money at you and gives you no-interest loans. There is not as much advertising (about

the heat pump program) as there was for the solar. I've noticed a lot more in the last few years, and it's the fuel companies, the HVAC companies, in the newspapers. (#4)

I got a Mass Save loan/dollars toward new insulation on the upper level. It was $600-700, and I think it cost $1200. And I got interest free loans. It was definitely a factor in making the changes – why not? Free money. I might not have gotten a new burner if I had not had this program. My burner was relatively efficient – over 80%, not bad for oil - but it was original to the house, which was built in '62. I think I'm now at 87-88% efficiency with the new burner. (#4)

There was a state tax write-off; I don't believe there was a federal (write-off). (#4)

Low Knowledge of Costs, Energy Saving and Environmental Impact

I wish I did (have a sense of how much the mini-split costs to run). I know it's much less (cost) than an in-window unit. There are these devices these days which actually tell you about your usage. I'm surprised Mass Save don't make that as part of their offerings. That would be a good way to determine what's efficient, what's inefficient. We all know large screen TV, unless you actually have them on a junction box that you turn off, they are on running behind the scenes and using quite a bit of power actually. (#4)

[Environmental impact] The mini-split, more than anything else. It uses a lot less energy than it puts out, the cooling quotient or heating quotient. I'm sure my burner burns cleaner (than the old one). (#4)

[If contractor or utility said 'Lower your environment impact if you used your mini-split more'] I would use it more. These people have lot more experience than I do. The installer told me he was using it during the shoulder seasons and thought he was saving money. (#4)

The mini-split has a remote. It's not connected to a thermostat. As part of my furnace I do have a sensor that is connected to my thermostat. That reads the temperature outside and adjusts the heat inside to optimally without over-heating or under-heating. It also senses moisture levels in the air. It's a smart unit. I might consider (putting my mini-split on a wireless smart thermostat), but right now, because of the cost of oil, I don't think it (makes sense). That would mean I would be depending more on the mini-split than I currently am. You know the price of oil will go up again, and when that happens, it might become smarter – both environmentally as well as financially – to use the mini-split more. (#4)

[Can reduce carbon footprint by 40%]. That's good, but I'd be surprised if it's that high. I might experiment with (using the mini-split more). I'm only burning like 600 gallons of oil a season now. It's about $123 a month. That's based on a dollar amount that the oil company calculates. You can no longer lock yourself in; you either pay fully upfront, monthly or by the fill-up. Monthly is better because you get automatic fill-ups and you don't have to cough up $300-400 every time the truck comes. It's a 10-month contract so it's about $1200. (#4)

PORTLAND WOMAN:

ASHP Acquisition Driven By Energy Efficiency, Environmental Impact, Cost & Convenience

We have a couple of heat systems, but our primary is an electric heat pump, a mini-split on the wall. We got that just within the last few years, replacing a Rinnai propane heater. It's still here but we really don't use it anymore. In some of the rooms that are a little farther out we have electric heat, and just to round out the picture, we do have a wood stove in the living room. The heat pump would be what I would describe as primary. We have a compressor and one internal (head)…We were hearing and reading a lot about (heat pumps) being very energy efficient, very green in terms of impact on the environment, and low cost. All those things matter to me…and the cost has been surprisingly low. (#11)

[Did you expect to use the heat pump as your primary heating system when you installed it?] Yeah. That's what we were looking for because we're retired. The wood stove, which we love, is very labor intensive. The propane, I knew, was just so bad for the environment. I really wanted something – if we were too old to use a wood stove – we had heat that was at a reasonable price. Even though there was an upfront cost – and that will amortize over the next 20 years and be great. So yes, we got it hoping it would be our primary heat, and it is. (#11)

[AC] No we don't have AC. The heat pump has air conditioning as one of the things it does but we never use it. We live on an island and we like our windows open. I'm loathe to close the windows, so no, we don't use it. The AC component to the heat pump was not something we cared about at all. We were looking for heat that used little energy, was kind to the environment and to our wallets. (#11)

[Esthetics] I think heat pumps are kinda 'in' right now, so having one hanging on the wall over the bookcase, nobody bats an eye because so many people are doing it. It wouldn't bother me anyway. We live on an island purposely and have a pretty rustic house. You already know I have a wood stove, so I've got wood stacked up next to it. It's a pretty small unit and it's quiet as all get out. (#11)

I didn't know (that we had reduced our carbon footprint by about a third). I love hearing that! It matters to me, but I don't want to be a hypocrite. If you'd told me that I could reduce my carbon footprint by a third but it would cost me twice as much, I wouldn't have done it. I can't afford to. But (the environment) was a factor, absolutely. (#11)

Awareness of ASHP Mainly Through Organized Neighborhood Environmental Group

I live on Peaks Island, which is part of the city of Portland, but a separate island. We have very much of a neighborhood feel and some neighbors had organized a group to have more buying power and get heat pumps at a discount. I went to the meetings; I didn't wind up joining that group, I waited a couple years hearing about it more. But honestly, so many people had them and were swearing by them that I went with it. As to the model, I left that (decision) to my HVAC guy – he knows that and I trusted him 100%. We knew him and went with him; we didn't get any other bids. (#11)

Honestly, I call it a heat pump. We always call it a heat pump. All the group emails and all the talk was about heat pumps. I wouldn't have (known about heat pumps) except for somebody in the community who got organized and started sending out emails about it. I don't think there is as much demand as other places. (#11)

It was an environmental issue. It was about using less energy to save the environment; this same group organized plastic window inserts. We do a community effort building and distributing window inserts that many of us use to cut down on heat loss. Living on an island is different. We're 15 minutes from the mainland, but it's a ferry ride. You have a couple people out here that get interested in something and get active…we have an environmental advocacy team, we have a half dozen things that deal with issues and the land preserve and all kinds of things. (#11)

Energy Audit & Incentives

I did look at the State of Maine page where I needed to go to learn about the rebate. There was (also) a tax credit, I forgot about that. I got a tax credit on (the heat pump) and on the windows and the water heater. My accountant told me about those. (#11)

Maine has a rebate that I think was about $500 that I just had to fill out a simple form and send in. It wasn't cheap; it was over $2000, after the rebate. (#11)

I can't remember exactly, but we had a home energy audit between two and three years ago, before we got the mini-split. There was no connection between the audit and the mini-split, but the home energy audit, but there was a rebate on the audit as well. It cost less than it would have if we'd had to pay full-price for it. (#11)

[Upgrades thru the audit?] Yes, they recommended we seal up the crawl space and we did. While they were doing it, they did some caulking around windows and stuff like that. We've done most of the things they recommended. (#11)

Our installer told us about the rebate and I think he had to sign the paperwork. We had also heard through the community listserv. There was a lot going around about heat pumps. I also kinda follow stuff, and there was plenty of publicity about rebates you can get for more efficient heating. (#11)

Estimating Energy Costs is Difficult

It's so hard (to estimate what we spend) because electric isn't just the heat pump; it's a number of other things in the house. With the propane, we also have a propane stove and water heater. I've never been able to really narrow down our heat costs. We also got the wood stove, which is atmospheric but also heats. Last year, we spent an average of about $50 a month for electric over the course of the year. That includes electric baseboards in two or three rooms that are not near where the heat pump is. We just turn those on if we're going into those rooms. (Our bill) used to be higher when we had an electric water heater; now we have an on-demand propane water heater. Then we also burned like four cords of wood last year too. (#11)

I'd have to do the math (on when we will recoup our upfront costs). Our electric bill is actually lower than before we got the heat pump, because we got the on-demand propane water heater. Our propane is lower because we're not heating the house with it, we're only using it for water, the stove and the dryer. So in order to calculate out the amortization, I'd have to do more math than I really want to. I already feel it was worth it to install the heat pump because the money that's spent is a sunk cost, and the money going out every month is lower. And the unit is quiet and it's efficient and it's using less energy that we did before. (#11)

Knowledge of the Technology and Process

It's slow, it doesn't heat the house fast, which I understand. Basically for a non-physicist, I understand how it works. There were some very, very cold days. So when we got in the single digits, zero-y kind of temperature, I was very glad we had the wood stove. The heat pump was working, but we weren't getting as warm as we wanted to be. I'm glad we had a backup. And as I said, we never took the Rinnai out though we haven't really used it, we could. You turn it on and you have a blast of fossil fuel heat in one second. I think we used it once this winter when we were sick, just to get the house up to temperature, and then we turned it off. It's just there as another option. (#11)

For installation, we used a local person, someone who we knew and he and his assistant came out that morning and finished that afternoon. It was pretty painless, really. (#11)

Harder was learning how the damn thing works. There is a learning curve and it is frustrating. The instruction booklet is not exactly user friendly. It was terrible. The installer also talked to us about how to use it but he didn't do a really great job. We love him; he's a great guy but I don't think he had installed a lot of them and he certainly isn't a teacher by trade. His instructions probably flew over our heads and he doesn't explain that well anyway. So it took us some time. I spent a lot of time googling YouTube videos and found some other HVAC organization that had put up a video so that I could really understand it. (#11)

We had actually heard that it can take some time to understand it and get it, because it is different. You don't turn it on and get this blast of 500-degree heat. It creeps. We also (worried) at first that if we had the wood stove going, the air conditioning might turn on. We didn't understand at first. Now we basically have it always on in the winter. We turn it down at night, we turn it up in the morning. We use a remote. It has allowed us to get a lot lazier about lighting the wood stove, which was our plan. (#11)

I didn't even know the option (to connect a heat pump to a thermostat) existed. I never thought about it. The remote does have settings – you can program it to turn on a certain time. We have done that, especially turn the shoulder seasons. We turn it off before we go to bed and program it to turn on before we get up, because it's not that cold. A thermostat would be convenient, I suppose. (#11)

There is an overhang over the outdoor compressor. But a couple times I've brushed snow off it when I was out there and noticed that snow had gotten on it. We walk by it enough to notice if wind was blowing and got on it, we would clean it off. We haven't noticed any problems. (#11)

3.2.5 HOW HOMEOWNERS WILL LEARN ABOUT ASHPS

Most Consumers Conduct Internet Research

New England homeowners expect to do most of their research about home heating and cooling options on the internet. "The internet, of course," an older Somerville man replies. However, until they have exposure and a little background knowledge about Air Source Heat Pumps, their searches are likely to gravitate toward the heating system already in place in their homes. A Northampton woman says, "I could research online. Google 'most efficient ways to heat a house' 'home furnaces' 'residential furnaces'." A Providence man agrees, "Internet – I would just Google it. That's how I investigated when I installed my

natural gas system." A younger Boston man concurs, "I'd probably start (researching) on my own, just googling 'HVAC systems,' maybe some trade journals."

> First looking online I can usually find out most of what I need to know and more than one place to find information. You dig around a little bit and you find out what people have said about it as well. I would (Google) Air Source Heat Pump or mini-split. I would variations on it if I couldn't get what I was looking for. (Before this interview) I would not have thought to look for something I had never heard of. It's possible I would have done a generic search for 'heating and air conditioning resources' or something like that. Sometimes you don't know what to ask. If you haven't heard of it, you might not get down that road. (#5)

> Online. I don't have a particular place. If I was replacing my heating system, my search would be based on honestly, just a general Google search. I'd type in 'heating system replacement options' and I would look into where are there tax credits or programs that might assist me. I'd also be researching what state programs and incentive programs might be offering. If I was just starting a search and I didn't know about heat pumps, I'm going in thinking I'm looking at natural gas and something comes up in my search that (heat pumps) are highly competitive with the other fuel options and has a nice package of incentives or rebates. (#7)

> Probably the internet. I would probably Google 'air source heat pump.' (#8)

> I would hope we had something in writing. And present it to the board – I would say one of the trustees would do that. I would do research on the internet too. (#13)

Testimonials Overcome Reservations About Heat Pumps

However, one of the clearest lessons from homeowners who have recently adopted ASHP technology – and those most likely to consider it – is the power of personal testimonials. A Boston woman says, "I might go to my neighbor who researched it when she was proposing to buy that." Hearing from friends and neighbors about the comfort, convenience, energy efficiency and cost savings that heat pumps provide is worth more than countless Google searches. Testimonials are powerful because of personal connections and the absence of any financial incentive. Information from an educational page managed by a local community group ranks as one of the top four sources homeowners would use to research heat pumps.

> The community group was my first exposure (to the heat pump). I probably googled it. Honestly it was that so many people I knew had one and were talking about it. I didn't really do much research. I went to a couple of meetings (of the community group) where they explained how they work. (#11)

> I'd certainly ask our neighbors (who have a heat pump). (#6)

> Friends that have had experience, then probably government. (#1)

Value of Independent Sources

Homeowners are looking for other trusted, credible sources for information about home energy options, and especially about a technology they are unfamiliar with. Several mention *Consumer Reports*. Again, they likely to value information that comes from unbiased sources without a financial stake in the technology.

Many would like to get feedback from energy auditors specifically. A younger Providence man says, "I would contact the local company that does the home efficiency (audit) and have them come out and do that and ask questions about (heating systems) while they are here." A younger Somerville man explains, "I would be more likely to use information (from an energy auditor). I gave most of the sources you cited around the same number, because I'm going to look at multiple sources and then decide. A contractor, an equipment manufacturer, an environmental group, they may have their own priorities. An independent audit I would see as more trustworthy." Many homeowners understand their utility is involved in the home energy audit process; utility program websites rank as one of the sources most likely to be used in researching heating and cooling options.

> Consumer Reports…consumer research & feedback, comparing different furnaces (#2)
>
> I would say one of the consumer publications would be good – like Consumer Reports and any other organizations similar to it. They don't take advertising, they just tell it like it is. They will test the units and report which units they think are best for a variety of situations, including cost and efficiency, rate of repair. I would trust Mass Save or a consumer publication. Obviously manufacturers themselves have got a lot to gain and they want to sell you a product. The oil company wants to sell you a product. (#4)
>
> I trust the sources that are neutral and not proprietary in nature, so…if I had National Grid telling me about it, the state government telling me about it, or I had a neutral audit done by an independent consultant – those are all sources I trust. If someone gave me this information as part of an audit, that would be the winning ticket because especially if it's coming from an objective neutral source, I'd be very inclined to hear why someone felt it was a good solution for my home. If it wasn't coming from someone trying to sell me the technology, just trying to make me aware of it and they were right there in the home pointing to it, that would be the home run for (this) technology. (#7)
>
> RISE [company that does energy audits], because it's an engineering group that is not funded 100% by consumers as their primary source of income. They are run like a coop and work with the government. They are not searching for only one way to fix the problem. (#5)
>
> There are companies that do those home energy audits and they help you figure out (what to do). In our old house we had one and we added ceiling insulation in the attic, and we figured out which cost effective things we could do to increase our energy efficiency. There are a lot of companies that do that. That's where I'd start with an existing house. (#12)

Industry Professional Sources Rank Above Government & Others

New Englanders are also likely to utilize home energy contractors and oil dealers when researching heating and cooling options. This is especially true if homeowners have long-standing relationships with the industry professionals. A Northampton woman volunteers, "(I'd talk to) my oil provider – I'm sure they install electric as well." An older Somerville man agrees, "I would probably inquire of our oil group, since they also advertise AC installation." A younger Boston man adds, "I would probably contact a friend of mine who works in HVAC." However, a younger Providence man is suspicious, "I would immediately assume

they're still gaining proprietary interest from it." Information from equipment manufacturers is valued, but usually later the decision-making process. A younger Providence man explains, "Only after I already decided to buy it would I be looking for all the specific details."

> I'd first probably talk to service people I'm working with now, like the guy who did my solar panels. Or my boiler people, I'd see what they had to say. Then if they are recommending a different system, I'd ask people who have experience with that system. How's it actually work, are you happy with it, what problems have you had? That's what I did with the solar. (#1)

> I know what I want, so I would compare getting a decorative propane stove as a space heater – I already have propane for my stove anyway – to the heat pump. I would just go – there's a place on 302 as you head up into Wyndam – that is a heat pump dealer. I'd probably go straight to the source and talk to the people there. A store that sells them would be the most knowledgeable about them so I would probably talk to them first. (#10)

Homeowners are more likely to use information from the federal government for heating and cooling options research than the state or local government. The federal government ranks just behind home energy contractors as a desired information source, probably due to interest in tax incentives for energy efficiency.

> With all the budget shifting going on at the federal level, I'd be skeptical that a great federal program would make it after this year. (#7)

> There are tax credits you can get. (#12)

> I presume the state would also have info as well. (#6)

> Town websites are usually not that intuitive and tend to be outdated and clunky, so I probably wouldn't bother. (#10)
> I love my town of Somerville, so I would see what they have to say. (#14)

> A city or government website would be most trustworthy. (#13)

People are less likely to seek out information from an environmental advocacy group. Strong environmentalists often assume they already know what the "environmental position" will be, or that they lack expertise in heating and cooling options. Those homeowners less likely to prioritize the environment assume an environmental advocacy group will be biased.

> That group organizes a window insert program. People volunteer to build those plastic covered wood frames (to prevent drafty windows in winter). They come out and measure your windows and make custom inserts. For something like that I would recommend them because that's what they do. They don't offer expertise (on home heating systems). (#12)

Three Bids is the Magic Number for Heating/Cooling System Installation

Homeowners prefer to use contractors recommended by trusted sources for major projects like energy system installation. However, almost everyone would still get bids from other contractors; three bids seems to be the ideal average. A younger Providence man describes, "I would compare three or four sources, it's not about finding one best source. If a contractor had a very good review, I would go with the same contractor about 80%. I would still research it and get about three bids total." Another Providence man asserts, "I'd be very likely (to use a contractor recommended by RISE). I'd probably look at least one other bid." A Boston man agrees, "I'd be very likely to go with a trusted recommendation; I'd probably get 2-3 bids."

> Recommended contractor…I would talk to them, but still call other contractors. They'd have to be authorized dealers. Maybe three others, or maybe more, depending on what they charge. Usually local people charge less because they're not adding on costs for travel. (#2)

> Very likely to use a contractor recommended…probably no more than three bids. Just to check the prices are in the neighborhood. I don't always go with the lowest, if someone comes highly recommended. I like to deal with people either I or someone I know has experience with. (#1)

> I'd certainly consider a recommended contractor; I'd have to talk to the contractor to know for sure. Generally I'm a multi-bid person; I'd get two or three bids. (#6)

> We usually do three bids. We have some long-standing contractors, but for anything new we usually do three bids. We might get information from one of our usual contractors. (#8)

> I'd shop around but I'd be inclined to use the recommended contractor. Not everyone does this stuff and I wouldn't want just Joe Schmo contractor installing it. I'd get two or three bids, just to see where people are at. (#10)

> We don't really use contractors too much. But if we had to, we'd be unlikely to get bids. We'd choose someone we know and ask for a price and make sure it's agreeable. (#12)

> (The condo board) would try to get three different bids, meet and discuss, check references. I think the board would make the decision as far as who the three contractors were, then put it out to the management company. If there were questions, they might ask owners if they wanted to be involved in the process. (#13)

> I would say I'd be very likely to use a contractor recommended by a trusted source. I would get other bids, probably 2-3. (#14)

3.2.6 ASHP TAKEAWAYS

After hearing a lot of information – both positive and potentially negative – about Air Source Heat Pumps, New England homeowners are asked what they believe are the best and worst reasons to consider ASHPs for their homes. They also get an opportunity to outline their outstanding questions about the technology.

Positive Aspects of ASHPs

New England homeowners describe best reasons to consider ASHPs as saving money, adding air conditioning and lowering environmental impact. It is critical that lowering energy costs is the centerpiece of ASHP promotion.

> Savings and environmental. If you're producing the electricity from the sun, it's cheap to run the air exchange thing. (#1)

> Uses electricity and my expense for electricity is lower than the average person…It's efficient generally. Heats and cools, which is really great. It would take care of the humidity (and it) can be tailored to individual rooms. (#2)

> Combining the heating and cooling might make it worth it…as a new homeowner, or someone who needed to replace their system. (#3)

> It is considerably more efficient than central air or window units. Efficiency translates to a couple of things. One, money out of your pocket and secondly, the environmental impact would be less. (4)

> Air conditioning in the summertime would be my favorite thing. (#5)

> Ecologically friendly, the addition of air conditioning, supplemental heating. The costs seem roughly the same. (#6)

> Demonstrating the cost savings over time and demonstrating the specifics of how it could be incorporated into my home, and the reduction of carbon footprint. (#7)

> Giving individual units control over their heating is huge, in my opinion. The other thing would be the air conditioning. (#8)

> In the Northeast, I'm not seeing too many great reasons to do it, especially in the cold winter months, especially because it is used to augment another system. Especially with the price of natural gas and oil competitiveness. That being said, heat pumps can cool off a certain floor for you, and there is a ductless system that they can retrofit for you, maybe that would be good. (#9)

> Saving money. I'm not going to spend more money just to have a cleaner source of energy. If I had more disposable cash I would, but it really comes down to bottom line dollars. (#10)

I would say the two best reasons are reducing your carbon footprint and reducing your monthly heating costs. (#11)

Good option, especially in an existing house…efficiency heating and the bonus of cooling. My sense is it's reasonably affordable, more environmentally friendly and more attractive than air conditioning units. (#12)

For the environment and also the cost savings. (#13)

Efficiency, the installation isn't so difficult, they are versatile and over the long-term I could save a good bit of money. (#14)

Less Appealing Aspects of ASHPs

Heat pumps are less appealing to New England homeowners due to the cost of electricity and questions about cold weather operation.

First thing is snow removal – that's really something I would not be interested in. Also the appearance – having equipment hanging from my house. (#1)

Require snow removal around the unit – if that could be minimized by having the unit installed higher up or protected with a cover or something so there wouldn't be a snow issue. If it doesn't work well in very cold weather…that doesn't sound like the best thing for me. I don't want to rely on two different heat sources…is that just in cold weather? (#2)

It's expensive compared to the other systems and it is not competitive compared to natural gas. How it performs in very cold temperatures is also a question mark. (#3)

If I was to see that it was costing me more in terms of electricity usage, that would be a downside. But I don't really have a handle on that. (#4)

Not knowing what type of apparatus would be required. Would it require structural change on the house? [If you knew it was only a 3 inch hole in the wall?] That's acceptable. (#5)

Having contractors in your house is always a bummer. How convenient the placement of the unit would be, especially for snow reasons. The necessity of having a backup unit and the ramifications of that. (#6)

Not cost competitive with other fuels, but that I should consider it because it is a better environmental choice. (#7)

Don't you have to tear up the walls? Holes in the walls would be a problem and the cost of doing it would be a problem. And we'd have to double check in terms of the cost of the electricity. I know I've read that electricity costs more and is projected to rise. I think we have some of the highest rates in the country. Gas is very cheap right now but again, we're wasting a lot. It would add to everybody's electrical bill, and lower to some degree, the cost to the condo for the gas. I could not do this on my own. This needs buy-in for a

huge number of people in the building. We usually like to have a decision as unanimous as possible. I have to go to the condo docs to see what is needed. I think it might take a real sales job to get people to come around. I think this is something they are all going to have to pay for, and it would be a $10-12,000 minimum special assessment, and then you're going to get higher electrical bills. I think there will be some people who will need to be persuaded. It could take a couple of years to get stuff like this pushed through. (#8)

The weather impact all around wouldn't seem valuable enough for me to do it. It doesn't have the utility I would need. (#9)

Nothing. You haven't told me anything that makes me want to get it any less. (#10)

If you're interested in instant heat, like with propane, if you're used to that, you have to get used to the concept of patience. I don't see any other downsides. I'm not even sure that's a downside; it's just getting used to it. (#11)

I have a generally positive view of them, except that they look modern and not that pretty. It's not a deal breaker, it's just not a plus. (#12)

The equipment in your unit, on the roof or outside the building – where to locate it. That would be the most concerning. (#13)

Looking at my current situation, I have a system I've invested a good bit of money in and it works pretty well. I want to get the most out of it what I have so that would prevent me from considering a heat pump right now…but down the line, perhaps in my next house, there is no reason I wouldn't consider it. (#14)

Remaining Questions About ASHPs

New England homeowners still have the most questions about the cost of heat pumps and the long-term prospects for technological improvements.

I'd have to have someone give me an estimate, do an analysis of the house where people look at the house and the insulation and the size of the rooms, the present heating system and auxiliary systems. If I could put this in, I could reduce the cost of obtaining the same comfort level I have now. (#1)

Not that I'm an engineer, but I'd like to have some sort of concept of how it really works, what I'm getting into, what really happens with it. I don't understand how a refrigerator works. I don't have to know the science, but I would like to know a little bit about it. (#1)

Is there a requirement for yearly maintenance or cleaning? Are they working on heat pumps that heat efficiently as a stand-alone? Even though you said they are getting better, they still don't work well in cold weather because they are recommending another alternative heat source. So that's not good enough. Is the cost coming down? (#2)

My main question is what is the cost actually? It runs on electric…does it work like a refrigerator? The efficiency is very good in that system. How big is it? How heavy is it? Do we need to drill a hole to install it? Is it through the window? What about the noise? How quiet is it? The refrigerator is sometimes not that quiet – is it louder than the refrigerator? Is there a condenser outside and does it look ugly? Durability is another issue – how long do they last? How quickly can you increase the temperature? How efficient is it? Will the price for the systems go down? Will the size of the unit get smaller? (#3)

How much electricity does it take? I have an old house with old wiring; would I need electrical upgrades before installing it? (#5)

Can you see the unit inside the room? (#9)

I would want to look into all the rebates. (#10)

A guarantee on the system, what's the servicing of the system? (#13)

SECTION 4 RENEWABLE THERMAL SOFT COSTS

This section discusses the impact of municipal regulations on the soft costs of residential renewable thermal technologies and identifies potential actions that cities can take to streamline these regulations and reduce associate soft costs.[31] As regulations vary from municipality to municipality, not all of the soft cost drivers and opportunities will apply, and cities will need to assess the impact of their own regulations on renewable thermal installations.

4.1 INTRODUCTION TO RENEWABLE THERMAL SOFT COSTS

One of the primary barriers to renewable thermal technologies is high upfront costs. The installed costs of renewable thermal technologies can be divided into "hard" costs (hardware-related costs) and "soft" costs, which are defined as all non-hardware costs, including financing, customer acquisition, permitting, installation, labor, inspection, taxes, and profit.[32] Several soft cost components can be directly affected by municipal regulations and ordinances—some of which can vary significantly from municipality to municipality.

The impact of soft costs on renewable energy systems more broadly has been the target of several government-led initiatives, particularly for solar photovoltaic (PV) installations, given that the U.S. Department of Energy (DOE) has estimated that soft costs account for approximately 64% of the costs associated with a new solar PV system.[33] For example:

- **The U.S. Department of Energy** SunShot Initiative has a soft costs program that has supported multiple local government initiatives, including the **SunShot Solar Outreach Partnership,**[34] the Rooftop Solar Challenges, and most recently the **SolSmart national designation program**,[35] to reduce the soft costs associated with solar PV related to permitting, planning, zoning, and interconnection codes, regulations, and processes. SolSmart recognizes communities that have adopted best practices and are leading the way in reducing soft costs for solar PV

[31] This memo does not discuss considerations for commercial- or industrial-scale renewable thermal installations given the scope of the CNCA grant and the more extensive permitting, planning, and customized installation processes involved.
[32] There are multiple definitions of soft costs used in various industries (e.g. in construction, soft costs are considered to be all non-direct costs related to construction). This memo uses the definition of soft costs established by the U.S. DOE's SunShot Initiative for solar PV (https://energy.gov/eere/sunshot/soft-costs).
[33] https://energy.gov/eere/articles/soft-costs-101-key-achieving-cheaper-solar-energy
[34] The SunShot Solar Outreach Partnership ran from 2013-2016. Additional information is available online at: http://solaroutreach.org/
[35] The SPARC program, now known as SolSmart is a national recognition and technical assistance program for local governments aimed at encouraging the adoption of best practices for reducing red tape and growing local PV markets. Additional information is available at: http://solsmart.org

- **The Massachusetts Department of Energy Resources** (DOER) received DOE SunShot Initiative Rooftop Solar Challenge grants to develop recommended model permitting processes and structural review guidance for rooftop solar PV in Massachusetts.[36]
- **The NY-Sun Initiative** includes multiple programs aimed at reducing solar PV soft costs. The **NY-Sun PV Trainers Network** provides no-cost education, training, and technical assistance to local government officials to help identify opportunities and mitigate barriers at the municipal level to drive the development of the solar PV market. **The New York State Unified Solar Permit** (and NY-Sun Solar Guidebook for Local Governments in New York State) was developed to encourage communities to adopt a single streamlined permitting process for all residential solar PV installations. As of September 2016, 124 of New York's 1,545 cities, towns, and villages had adopted the permit.[37]

Minimal similar action has occurred for renewable thermal technologies, due in part to lack of awareness and existing processes that encompass all heating, ventilation, and air conditioning (HVAC) equipment. Nonetheless, soft costs similarly account for a significant proportion of renewable thermal installations with studies showing that soft costs account for 50%-70% of the installed costs of these technologies.[38] The NYSERDA *Renewable Heating and Cooling Policy Framework* (released in Feb. 2017) provided an estimated cost breakdown for residential and small-commercial ground source heat pumps (GSHP), air source heat pumps (ASHP), and solar hot water (SHW) installations, as shown in the figure below.

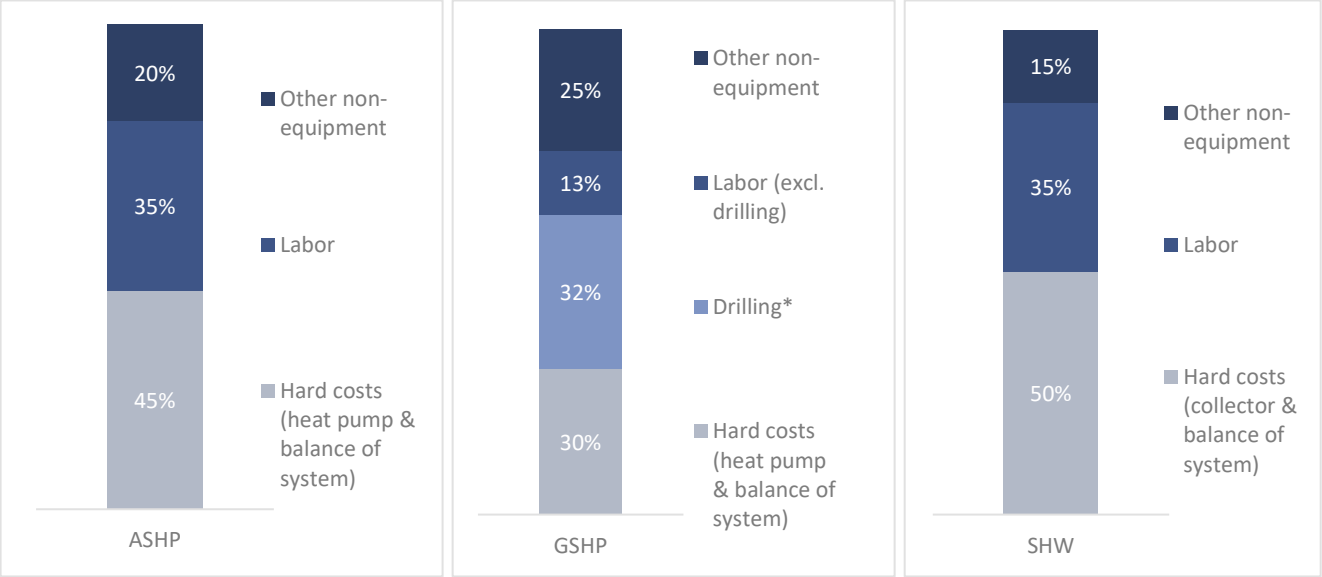
Figure 1. Typical cost components of residential ASHP, GSHP, and SHW installations[39]

[36] Navigant Consulting. (2013). *Recommended Model Permitting Processes and Structural Review Guidance for Rooftop Solar PV in Massachusetts*. Prepared for the Massachusetts Dept. of Energy Resources. Available online at: http://www.mass.gov/eea/docs/doer/renewables/solar/recommended-model-permitting.pdf.

[37] Additional information on the New York State Unified Solar Permit can be found here: https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Communities/Clean-Energy-Communities-Program-High-Impact-Action-Toolkits/Unified-Solar-Permit

[38] NYSERDA. (2017). *Renewable Heating and Cooling Policy Framework: Options to Advance Industry Growth and Markets in New York*. Available online at: https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/NYSERDA/RHC-Framework.pdf; Veilleux, N. and Rickerson, W. (2013). *New York City Solar Water Heating Roadmap*. Prepared for City University of New York. Available online at: https://www.cuny.edu/about/resources/sustainability/solar-america/solarthermal/CUNY_NYC_Solar_Thermal_FINAL.pdf;

[39] NYSERDA, 2017.



**Note: Drilling costs represent primarily soft costs, but also include ground loop material costs (approx. 5% of total installed costs)*

4.2 OPPORTUNITIES TO REDUCE RENEWABLE THERMAL SOFT COSTS

Similarly to solar PV, actions related to municipal regulations, policies, and programs can directly and indirectly affect the soft costs associated with renewable thermal installations, and therefore local governments can take action to reduce the costs of these technologies and foster increased deployment. In general, it is expected that some of the soft costs will decline with increased market scale.[40] However; municipalities can take actions to achieve modest reductions in renewable thermal soft costs. This section discusses soft costs related to permitting, taxes, customer acquisition, and financing as they pertain to municipal governments.[41]

Permitting

The permits and associated fees required for a RH&C installation can vary widely from municipality to municipality depending on the technology involved.[42] Standardization across municipalities and states can dramatically reduce direct and indirect permitting costs. In general, the installation of residential renewable thermal technologies may require: building, electrical, plumbing, mechanical, and/or HVAC permits, depending on the technology and municipality

[40] NYSERDA, 2017.

[41] Other municipal regulations (e.g. zoning, historical preservation) can inhibit the deployment of some renewable thermal technologies. These are not explored in this section, given that these regulations can often prohibit the deployment of relevant technologies and tend to be particularly challenging to modify.

[42] The renewable thermal technologies included in the scope of this CNCA project include ASHP, GSHP, SHW, central pellet heating, and heat pump water heaters (HPWH).

- **ASHP** installations typically require building and electrical permits, and, if required, HVAC (e.g. Portland) and mechanical (e.g. Providence) permits. ASHPs are typically not treated differently from conventional HVAC equipment, given their similarity to central and ductless air conditioning systems.
- **GSHP** installations typically require similar permits to ASHP for installation of indoor components. Installing a desuperheater[43] alongside a GSHP for domestic hot water can also require a separate plumbing permit. Additionally, depending on state and local regulations, additional permitting may be required due to drilling/trenching and installation of an outdoor loop.[44] In Massachusetts, for example, the installation and operation of a GSHP well must be conducted in accordance with the Underground Injection Control, Groundwater Discharge, Well Driller Certification, and Water Management Act Programs administered by the Massachusetts Dept. of Environmental Protection.[45] Open-loop systems may be subject to further regulations due to using groundwater as the heat exchange fluid. Some cities may have additional requirements for GSHP installations (esp. open-loop systems), particularly where groundwater conservation-related restrictions are involved.
- **SHW** installations typically require building, electrical, and plumbing permits, as well as HVAC and mechanical permits if required. SHW may be subject to a special permitting fee and process if the municipality has adopted special processes for solar technologies.
- **Central pellet heating** installations typically require building permits, may require electrical permits, and, if required, HVAC and mechanical permits. Depending on the municipality, pellet boilers and furnaces may be treated like conventional boilers and furnaces but may also be subject to separate regulations or require special permits for wood/pellet stoves or solid fuel-burning appliances (e.g. due to air pollutant issues).
- **Heat pump water heaters** typically require electrical and plumbing permits. HPWHs are typically treated as electric water heaters.

In most cases, permit requirements cannot be waived due to important customer safety concerns, and the ability to modify fees may be limited. However; there are still several opportunities to streamline the permitting process that can reduce costs for the contractor, city, and homeowner.

- **Online permitting** can help to expedite the permitting process, eliminating travel time and associated costs with hard copy or in-person submission. Notably, online permitting is offered at all but one of the five participating cities (which is in the process of developing an online permitting platform), though many smaller cities and towns do not offer online permitting.[46]

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[43] Desuperheaters use superheated gases from the heat pump compressor of an indoor GSHP unit to heat domestic hot water.
[44] Ground source heat pumps use an outdoor ground loop buried in the ground to exchange heat with the earth. While most systems installed in New England are closed-loop systems, circulating a glycol heat exchange fluid, others circulate refrigerant (direct exchange) or use ground water (open-loop), which can trigger additional regulations.
[45] http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/gshpguid.pdf
[46] Northampton is in the process of developing a fully integrated online permitting system. As of March 2017, building permits and fees were required to be filed in hard copy.

- **Creating a RH&C technology landing page** on the municipal website. Many cities and towns have dedicated solar PV pages on their website with resources, links to permitting and zoning requirements, etc. similar landing pages for RH&C technologies can help demystify the process and provide resources and information to those interested in installing these technologies.
- **Provision of checklists and clear requirements** for renewable thermal technology installations can help to ensure that contractors provide all required materials on the first submission, reducing added costs associated with multiple submissions for the same installation. This practice has been adopted in some municipalities for solar technologies,[47] though it is uncommon for renewable thermal technologies that lack special permitting requirements (e.g. pellet heating). Checklists help save time and money for both the installer/owner of the system, as well as municipal staff charges with reviewing and approving permits.
- **Eligibility for streamlined/fast-tracked permitting** for installations of renewable thermal technologies, which provides a faster, guaranteed permitting and inspection process, can reduce the time to installation, unnecessary inspections, and provide a more predictable review schedule to reduce additional costs to the contractor. Three of the cities offer fast-tracked permitting for one-, two-, and sometimes three-family buildings. If the goals of the municipality are to encourage the adoption of these technologies, then streamlined permitting processes can be justified to help reduce the costs of these technologies and increase the adoption rates.
- **Flat permitting fees** instead of valuation-based methods can reduce permitting costs for some renewable thermal technologies, given that renewable thermal technologies cost significantly more than conventional technologies even though some may not require any additional work. Eliminating and reducing permitting fees for these technologies is also a way to provide incentives at the local level.
- **Technology-ready building requirements** can reduce the cost of installing a renewable energy technology on newly constructed buildings. While the high initial cost of technologies like solar PV and some renewable thermal technologies like solar thermal may prevent their inclusion in a new construction project, accounting for the potential to install these technologies during the design and construction of the building can reduce installation costs if the occupant decides to move forward in the future.[48] Providing requirements or guidelines in building codes or other local regulations can help to ensure that more buildings are technology-ready.

Some New England cities are also exploring opportunities for using the permitting process to provide incentives or facilitate the deployment of energy efficiency and clean energy technologies more broadly. Box 1 below provides additional information.

It is worth noting that the departments charged with issuing permits and conducting inspections may often lack capacity (and political direction) to modify these procedures. The issuance of clear best practices and

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[47] E.g., see City of Boston solar permitting brochure: https://www.cityofboston.gov/images_documents/SolarPermittingBrochureHZEv4_tcm3-37565.pdf

[48] Lisell, L., Tetreault, T., and Watson, A. (2009). *Solar Ready Buildings Planning Guide*. Golden, CO: National Renewable Energy Laboratory. Available online at: http://www.nrel.gov/docs/fy10osti/46078.pdf

guidance must be backed by strong political will from leadership, or it is unlikely that modifications to these processes will be made. For example, the SolSmart program from the Dept. of Energy attempts to tackle this issue by offering Bronze, Silver, or Gold status recognition for municipalities and counties taking action, and has resulted in over 100 communities across the country participating thus far, with a goal of 300 communities by the end of 2018.

Box 1. Opportunities to use the permitting process to directly incentivize or facilitate deployment of energy efficiency and clean energy

Some cities and regional organizations have identified opportunities for using the permitting process to directly support deployment of renewables and energy efficiency.

- As part of its Net Zero Action Plan, **City of Cambridge** (MA) suggested exploring the opportunity for using a building energy performance-based incentive built into the permitting process to incentivize high-performance buildings. Through this modified permitting schedule, a contractor would need to pay a deposit at time of permit application, with a refund provided based on energy performance on a sliding scale (with highest performing buildings receiving the deposit in addition to rebates).[49]
- The **USGBC Massachusetts Chapter's Residential Green Building Committee** examined a pilot program to streamline application to Mass Save and MassCEC incentive programs through using the City of Boston's online building permit portal. Through the proposed process, an online permit application would include a checkbox to confirm that the contractor has made the homeowner aware of available incentives, and building permit information would be passed on to Mass Save/MassCEC, who could then reach out to the homeowner and encourage them to also complete energy efficiency work (and receive incentives) as part of the scope of building work. Incentive application could then be built into the permit process, with incentives issued upon permit approval.[50]

Customer Acquisition and Education

Depending on the technology involved, and the business practices of the contractor, customer acquisition costs can account for a significant part of the installed cost of a renewable thermal technology. Community-based purchasing campaigns—like Solarize for solar PV and the renewable thermal campaigns to be completed through the CNCA program—aim to reduce customer acquisition costs and provide volume discounts by aggregating high-quality customer leads (with savings typically passed onto the customer in the form of discounted or tiered pricing structures). These programs also serve to increase awareness of

[49] Cambridge Getting to Net Zero Task Force. (2015). The Path to a Net Zero Cambridge: Summary of Proposed Actions. Available online at: http://www.cambridgema.gov/CDD/Projects/Climate/~/media/BF531928BB7D4526AE2D8538E025E0BA.ashx

[50] Sun, P., Butler, B., Pignatelli, M., et al. (2017). *Energy Efficiency Program streamlining with ISD Initiative*.

the technologies and provide independent technical and expert assistance as these technologies are relatively new and unknown to many customers.

Broader outreach and education programs beyond purchasing campaigns—including those that provide educational materials, economic (e.g. "home energy savings") calculators, and tools to identify reputable local contractors—can also support deployment of renewable thermal technologies. These programs may have a limited, indirect effect on soft costs in addition to addressing key market barriers to deployment related to customer awareness.

Taxes

Tax policies and incentives such as property or sales tax exemptions are typically determined at the state or federal level: for example, Massachusetts provides a property tax exemption for solar/wind energy systems and a residential tax credit for solar and wind (including solar hot water), [51] as well as a sales tax exemption for solar, wind, and heat pump systems.[52] Some cities may provide tax credits for renewable energy technologies—for example, New York City provides a four-year tax abatement for solar installations.[53] Municipalities seeking to encourage adoption of these technologies can consider the feasibility of adopting similar local tax incentives.

Financing

Low-interest loan programs with long terms (e.g. >10 years) can help homeowners to overcome upfront cost barriers to renewable thermal technologies. While many municipalities offer income-eligible loan programs, financing programs are typically offered by utilities and utility programs, state agencies, and other private actors. For example, utilities and utility programs in Massachusetts and Rhode Island offer a 0% HEAT Loan for some renewable thermal applications, and Efficiency Maine provides multiple home energy loans.

Property-Assessed Clean Energy (PACE) financing is another financing mechanism that directly involves a municipality. Through PACE financing, a property owner finances an energy efficiency or clean energy project through a property tax assessment. PACE financing can allow for significant energy investments offer longer payback periods (up to 20 years), as the lien is attached to the property and transfers to the new property owner upon sale. While the cost of financing for PACE may not necessarily be lower than other options at current interest rates (and long loan tenor can ultimately *increase* the cost of financing), access to long-term financing options to overcome high upfront costs is considered a significant barrier to deployment, and longer-term financing can enable energy savings to cover the cost of loan payments. PACE loans can also provide an opportunity to address "split incentive"[54] market barriers: with the PACE financing payments provided through property tax garnishment over a longer period of time than other

[51] http://programs.dsireusa.org/system/program/detail/146; http://programs.dsireusa.org/system/program/detail/144
[52] http://programs.dsireusa.org/system/program/detail/145
[53] http://www.nyc.gov/html/gbee/html/incentives/solar.shtml
[54] The "split incentive" describes situations in rented buildings where investments in energy efficiency or clean energy technologies are made by the landlord, but the benefits of these investments accrue to the tenants.

financing options, the costs of financing renewable thermal and other clean energy/energy efficiency improvements can be more reliably passed onto tenants (e.g. directly through lease forms).

PACE-enabling legislation must first be passed at the state level, then municipalities. As of March 2017, commercial PACE programs were available in Maine, Massachusetts, and Rhode Island, though only Maine offers residential PACE financing (administered through Efficiency Maine for homeowners in towns that have passed PACE-enabling ordinances).

APPENDIX 1: SAMPLE OF MARKET SEGMENTATION MAPS

A sample of the market segmentation maps developed based on the suitability indices for each city is provided in this Appendix. The full market segmentation maps and indices can be viewed here: https://mc-group.box.com/s/r4uj24377nn0bbflvj99wquurqwidfbm

Figure 2. Parcels by fuel type in Northampton, MA

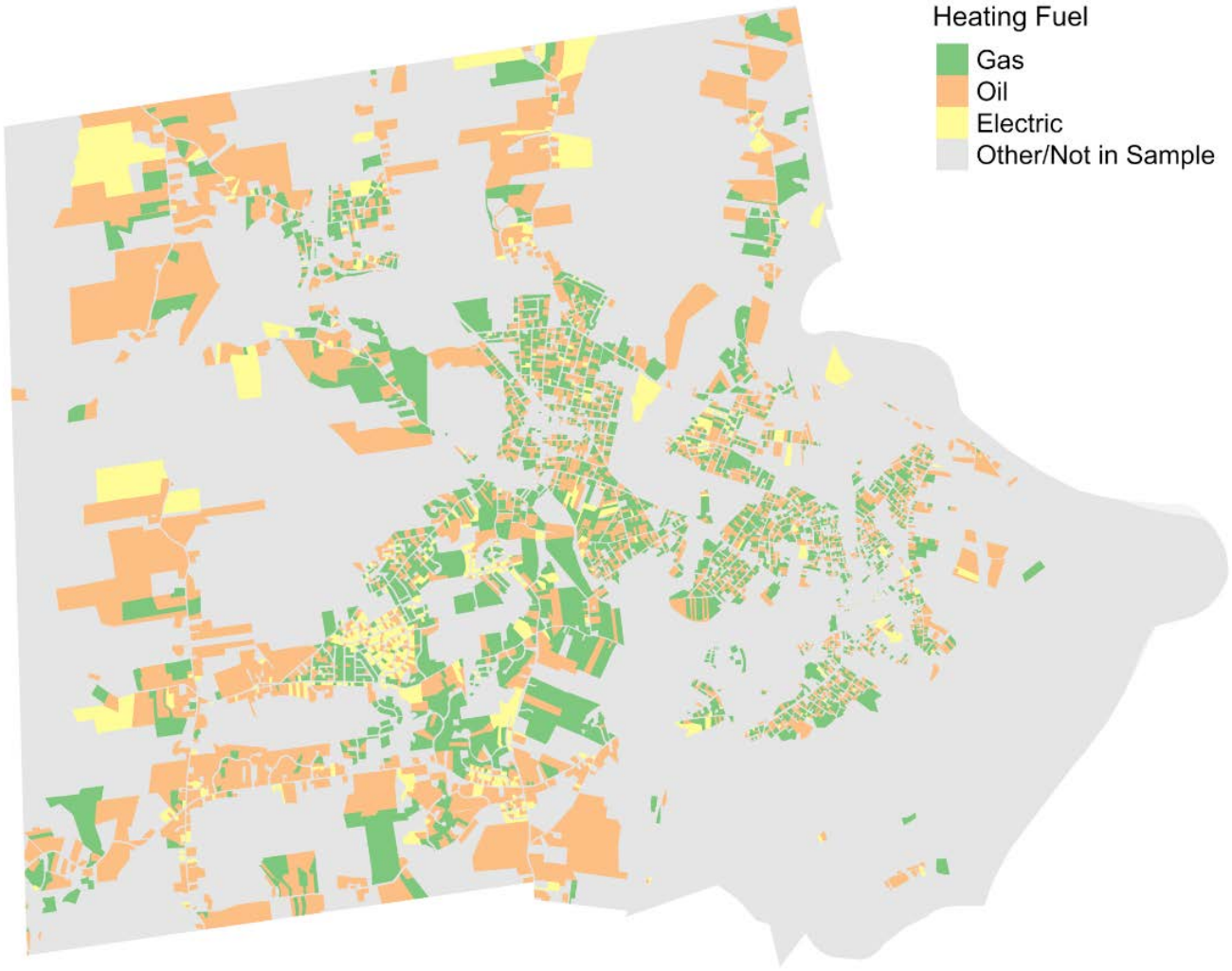


Figure 3. Owner- and renter-occupied properties in Portland, ME

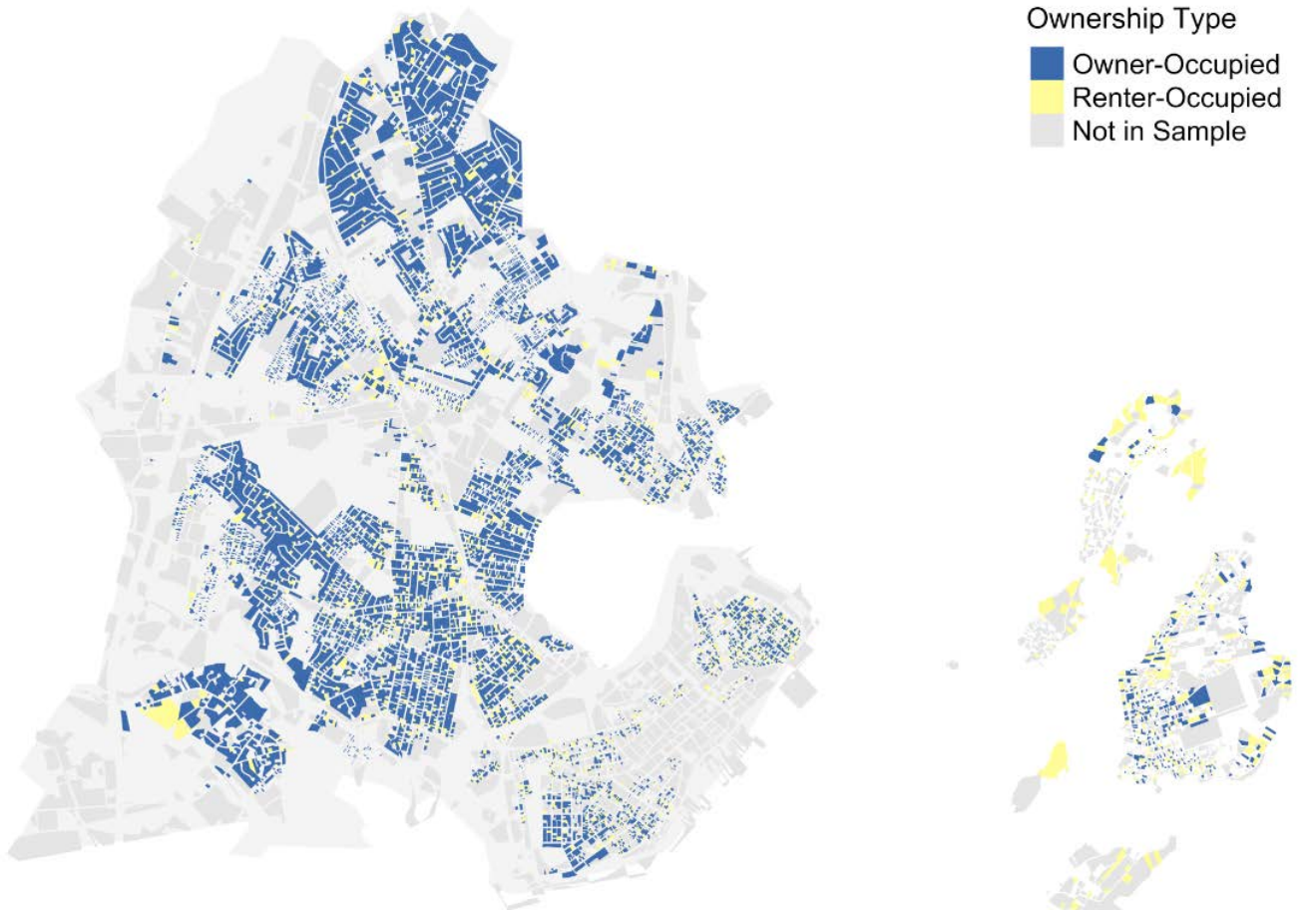


Figure 4. Ductless ASHP index results for Boston, MA (site-suitability only)

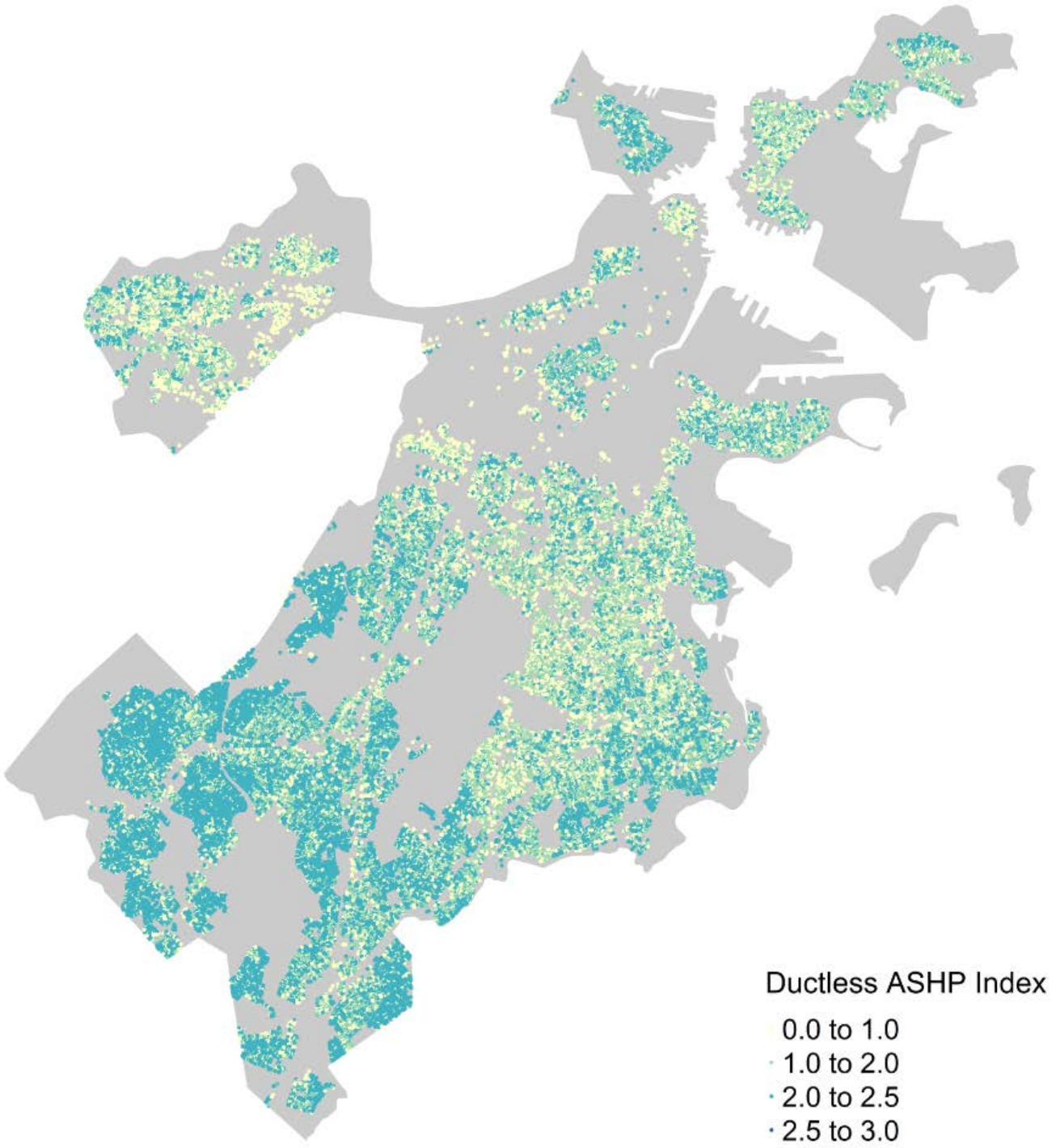


Figure 5. Ductless ASHP index results for Boston, MA (likely-adopter index)

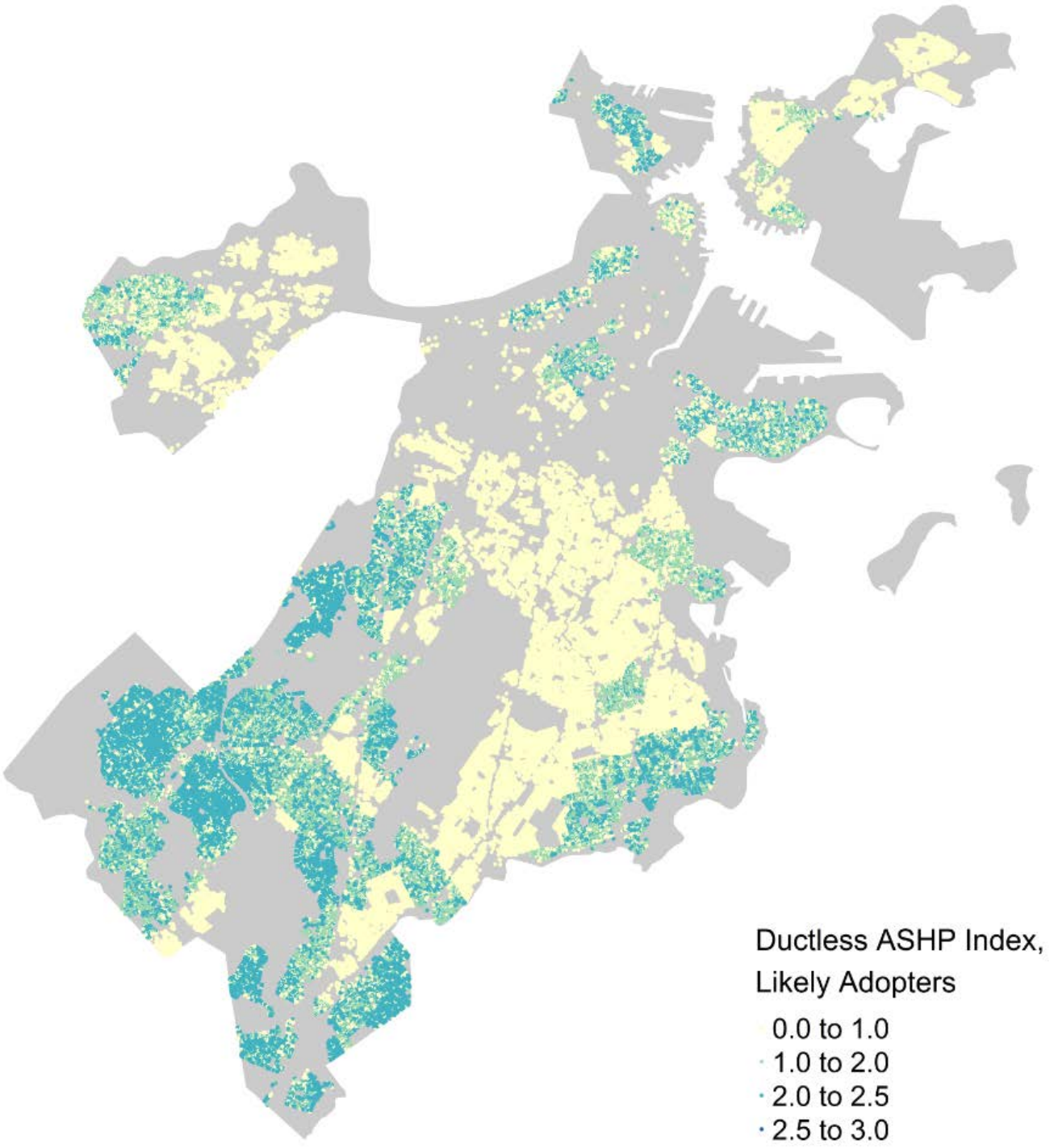
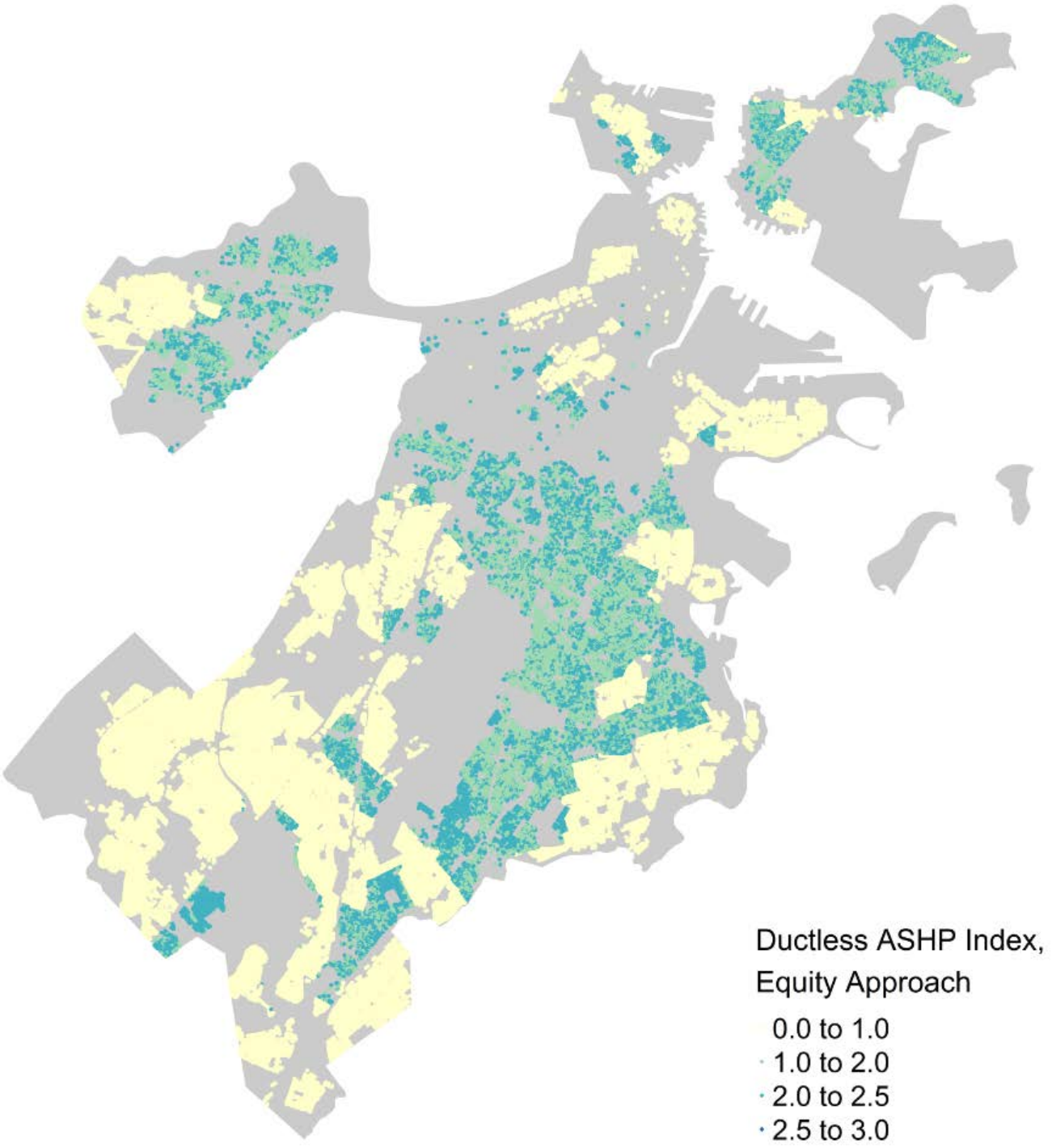


Figure 6. Ductless ASHP index results for Boston, MA (equity-focused index)



APPENDIX 2: INTERVIEW RESPONDENT DESCRIPTIONS

Descriptions of the fourteen individuals interviewed are provided in the table.

#	City	Gender	Age Group	Primary Heating	AC Status	Other Energy Actions and Notes	Income Group	Education	Household members
1	Northampton	Male	60+	Oil (forced air)	Central	Completed Mass Save audit & improvements; installed solar PV	<$60,000	Masters	2; no kids in college
2	Northampton	Female	60+	Oil (hydronic)	Window	Installed solar PV	<$60,000	Graduate degree	1; no kids in college
3	Providence	Male	36-59	Gas (forced air)	Central	Installed solar PV	$60,000+	PhD	2; no kids in college
4	Northampton	Male	60+	Oil (hydronic)	ASHP	Installed ASHP; Completed Mass Save audit & improvements	<$60,000	PhD	1; no kids in college
5	Providence	Male	36-59	Oil (hydronic)	None	Installed pellet stove	<$60,000	PhD	2; no kids in college
6	Somerville	Male	60+	Oil (hydronic)	None	N/A	<60,000	College	2; no kids in college
7	Providence	Male	36-59	Oil (hydronic)	None	N/A	$60,000+	Masters	2 (one on the way)
8	Boston	Female	60+	Gas (hydronic)	Window	Lives in condo/townhouse	$60,000+	College	1; no kids in college
9	Boston	Male	36-59	Gas (hydronic)	Window	Completed NSTAR energy audit and improvements	$60,000+	JD	1; no kids in college
10	Portland	Male	36-59	Oil (hydronic)	None	N/A	$60,000+	Masters	4; no kids in college
11	Portland	Female	60+	Propane/ASHP	ASHP	Completed home energy audit and improvements	<$60,000	2 Masters	2; no kids in college
12	Portland	Female	36-59	Elec resistance + wood stove	None	Lives in super-insulated home (passive house standard)	$60,000+	JD	4; 2 kids in college
13	Boston	Female	60+	Gas (hydronic)	None	Condo	<$60,000	College	1; no kids in college
14	Somerville	Male	36-59	Elec resistance	Wall	N/A	$60,000+	College	1; no kids in college