Air Source Heat Pump Market Characterization Report

Center for Energy and Environment

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CONTENTS

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EXECUTIVE SUMMARY

Overview and methodology

The Minnesota Efficient Technology Accelerator (ETA) is launching an air source heat pump (ASHP) market transformation initiative, focusing on accelerating the adoption of dual fuel, centrally ducted ASHPs. This application type can replace central air conditioners and displace a portion of heating from propane or natural gas furnaces. Market characterization work was needed to identify market barriers, opportunities, and dynamics and successfully launch the initiative.

This report characterizes the ASHP market and was conducted internally by CEE staff given their in-depth knowledge of and recent research work on ASHPs. The report summarizes key findings from recent contractor interviews conducted by CEE staff (N=18), internal knowledge gleaned from the Minnesota and Midwest ASHP Collaboratives, and applicable insight from literature reviewed, primarily from two key reports:

- **Investigation of Air Source Heat Pumps as a Replacement of Central Air Conditioning**, referred to as the 2022 CEE AC Replacement CARD Study; and
- **Understanding Market Barriers and Opportunities for Cold Climate Air Source Heat Pumps in Residential Households,** referred to as the 2020 Cadmus Cold-Climate ASHP Study

Key findings

Current market state

The primary path-to-purchase route for ASHPs follows the traditional HVAC product route from manufacturers to distributors to contractors and customers. While there are additional pathways including online DIY and big box retail store connection points, we anticipate these are much smaller than the traditional pathway. Currently, contractors and customers are a large leverage point for increasing ASHP adoption as there is skepticism and limited demand from these actors. Additionally, customers are generally operating in an emergency replacement market, primarily upgrading equipment when their current equipment fails or is malfunctioning, which adds strain to customer and contractor decisions. This dynamic will be important to consider in market strategies.

Baseline market perceptions

Each of the market actors in the traditional path to purchase are critical to understand and engage in this market transformation initiative. Key takeaway perspectives identified in the 2022 CEE AC Replacement CARD Study, 2020 Cadmus Cold-Climate ASHP Study, and our own recent contractor interviews are bulleted below.

Customer perspectives

- Homeowners lack awareness of ASHP technology, but utilities and other key sources could be trusted messengers.
- Homeowners believe in ASHP cooling capabilities. but are satisfied with their current cooling systems and operate in a replace-on-fail market.
- Heating capability skepticism remains among a small amount of homeowners.
- Perceptions vary by geography, heating type, and demographics.
- Customers describe performance, equipment costs, and operating costs as key decision-making factors.
- Energy efficiency is also important.
- Costs may be prohibitive.
- Incentives can help reduce costs and increase value proposition.

Manufacturer and distributor perspectives

- More ductless options are currently available, but the opportunity for centrally ducted dual fuel is attractive.
- Lack of awareness and familiarity by customers and contractors is a perceived issue.
- Manufacturers and distributors indicate some skepticism among contractors around cold-climate performance.
- Distributors felt competitive advantage and innovative distinction could be a selling point for bringing more distributors and contractors along.
- Manufacturers and distributors indicated additional customer benefits, including fuel choice and flexibility.

Contractor perspectives

- Contractors view ASHP technology favorably but are skeptical of heating performance.
- Mixed messages on cooling - contractors believe ASHPs are a good choice, but do not always recommend them.
- Contractors expect ASHP sales to increase.
- Demand for ASHPs is minimal and a challenge.
- Contractors see performance, costs, and the potential for financial savings as key to customer value proposition.
- Contractors described a replace-on-fail dominant market.

Costs and related value proposition

ASHPs have higher product costs than baseline equipment (distributors described costs 50% higher or more), which can hinder adoption. ASHP upfront costs also increase significantly with more product advancements and cold-climate capabilities. In addition to high upfront costs, contractor bids can be highly variable for similar equipment.

Utility rebates can play a part in mitigating this upfront cost barrier. However, in 2023, rebate amounts range from $50 to $2200, which may not cover the full incremental cost and reduces the cost barrier more for some than others. Moving forward however, there will be increased attention and funding from state and federal sources around electrification and specifically heat pump technology, aimed to reduce upfront costs.

Value proposition also considers ongoing operating cost, which varies by fuel type, home type, and how systems are designed. Due to the high fuel costs of existing propane and electric heating, ASHP value propositions in those application types are largely attractive. They are also positive for homes looking to add air conditioning. However, given the low natural gas cost relative to other fuel types, the value proposition can be more challenging in natural gas heated homes.

Electric rates, which vary by utility, then can make dual fuel ASHPs increase operational costs, remain cost neutral, or save customer costs. To make the value proposition more consistently positive for natural gas customers, rates can be optimized, such as through creating dual fuel, interruptible rates that dramatically lower standard electric rates. These rates can be justified from multiple perspectives and can lower economic barriers.

Overarching market barriers and opportunities

Key barriers and opportunities were presented across stakeholder types and research initiatives. The primary barriers and opportunities for this initiative to begin focus on are summarized below.

Barriers

1. **Limited product experience, skepticism of cold-climate performance, and past negative experiences** – While it appears that contractors and customers are becoming more familiar with ASHPs and have mostly positive perceptions of the technology, skepticism around ASHP efficiency in cold climates, limited experience, and past negative experiences are all still barriers to broader adoption.
2. **Replace on failure nature of residential HVAC –** Customers and contractors indicated that while they may want to be proactive, they are primarily replacing equipment when their current system fails, which creates a number of financial, availability, and time constraints given the urgency of the need.
3. **Variable value proposition across application types -** The value proposition for ASHPs comprises upfront cost, operational cost savings potential, performance, and other perceived benefits of the technology that can be unrelated to cost. Upfront costs and operating costs can vary significantly from customer to customer depending on product

bids, incentives available, fuel type, and fuel rates, all of which are variable throughout the state. This inconsistency can be challenging for contractors and customers to navigate.

4. **Lack of customer awareness and demand for ASHPs –** Most potential customers are not aware of ASHPs, leading to a lack of customer demand. Contractors indicated this was a bigger challenge than any other barrier asked about, and distributors and manufacturers also see this as a challenge for adoption.
5. **Lack of utility program consistency and stocking –** Rebate programs, product specifications, and rebate amounts vary widely across Minnesota's numerous utility territories, making it challenging for distributors to stock qualified products and for customers and contractors to navigate and leverage rebates.

Opportunities

1. **Unprecedented federal, state, and utility incentives** – There is a large influx of rebate and tax credit program funding from multiple levels around electrification, many specifically supporting heat pump technology. These incentives can often be stacked for greater benefit, greatly reducing upfront costs. However, this needs to be approached with care and navigational resources as different parameters and product specifications for different programs can be confusing for customers, contractors, and distributors trying to stock and buy products.
2. **Electric rates optimization and demand response incentives –**The payback period for customers electrifying space heating can improve with lower electric rates. Utilities can benefit from dual fuel interruptible rates and other demand response incentives that allow the utility to manage electric load during surge pricing and encourage peak load reductions,. Thus, supporting rate optimization through activities like utility technical support and regulatory process participation, can help accelerate adoption.
3. **Local government climate action and public awareness** – Many local government entities have or are creating climate action plans and funds to promote technologies like ASHPs to mitigate global climate change. There is an opportunity to deepen engagement with these entities, leverage this interest, and use robust public networks of constituents to encourage ASHP adoption.
4. **Broader decarbonization trends –** Market actors, customers, utilities, and government entities are looking for ways to achieve decarbonization, and ASHP technology is being recognized as a way to help reduce carbon footprints. This recognition, combined with other global factors like increasing natural gas costs and state and federal legislation, is motivating increased sales as well as additional research, development, and deployment around ASHP products.
5. **State and federal codes and standards** – Codes and standards are often leveraged as a market transformation strategy, especially for technologies like ASHPs with fewer non-energy benefits, but clear energy savings and a clear code requirement pathway. Future state code or federal appliance standards could contain language making ASHPs standard practice, in place of CACs.

Recommendations

Based on the previous research and ASHP collaborative program experience, the team compiled the following five broad recommendations for the ASHP initiative to consider for the next three to five years.

1. **Work to improve upfront cost, operational cost, and overall value proposition for customers** – Costs are very important to homeowners and are a barrier in purchasing new equipment. Reducing costs can be key for creating a positive value proposition, as well as highlighting other valued benefits, like upgrading to new and better technology or reducing environmental impact. Clearly defining these value propositions across application types, working to make them as enticing as they can be (e.g. with financial incentives, operating cost impacts, and additional non-cost benefits), and ensuring appropriate messaging can help bolster product adoption.
2. **Support increase of contractor knowledge, comfort, and experience — cultivate heat pump champions** – While there are generally favorable opinions about ASHPs, there are still hesitations to install them, particularly with natural gas applications, and lots of variability in service offerings across the state. The program should thus work to offer training and support to develop contractor knowledge and experience and highlight contractors who are successful via the preferred contractor network, cultivating heat pump champions.
3. **Support increase of customer awareness** – Lack of customer awareness is a large barrier to adoption, and the ETA can play a valuable role in aligning and strengthening customers awareness and marketing activities. The ETA can lead collaboration across entities to ensure program coordination, and develop consistent customer messaging, tools, and resources.
4. **Leverage decarbonization trends** – ETA can harness the broader trends and funding around decarbonization via supporting program and product specifications alignment, building awareness of funding streams and braiding opportunities, providing effective messaging and materials, and engaging with and tracking other programs and policy efforts.
5. **Codes and standards improvements** – To support market saturation of ASHPs, long term, ETA should pursue state residential code or state or federal appliance standard measures to propel ASHPs into market saturation. In the first few years of the initiative, the ETA could explore different pathways and determine the most viable approach.
6. **Future research** – Finally, there are still several gaps in market knowledge and areas where additional ongoing research insights could be helpful. Research priorities could include greater insights into direct-to-customer retail sales, ongoing contractor surveys, and additional customer research.

INTRODUCTION AND BACKGROUND

In July 2022, Minnesota Department of Commerce approved a market transformation portfolio as proposed by Center for Energy and the Environment (CEE) known as the Minnesota Efficient Technology Accelerator (ETA). This proposal included an initial portfolio of projects, including one focused on promoting air source heat pumps.

This ASHP Market Transformation Initiative focuses on dual fuel air source heat pumps (ASHPs) meaning a heat pump that replaces a central air conditioner and displaces a portion of heating from a propane or natural gas furnace. Currently, an estimated two-thirds of single-family Minnesotan households heat their homes with propane and gas furnaces and could instead meet a portion of their home heating needs by replacing their central air conditioner (CAC) with an ASHP.[1] By moving heat instead of creating it, ASHPs heat homes more efficiently and contribute to reducing emissions in line with the transition to a carbon-free grid by 2040 in Minnesota. The purpose of this initiative is to remove market barriers and leverage opportunities identified in this market characterization, with the end goal of enacting a code or standard by 2035 that will make ASHPs, instead of CACs, the standard choice for home heating and cooling.

To set the initiative strategies on the most effective path, ETA compiled current market dynamics and insights. CEE conducted the market characterization in-house as CEE has extensive experience with the ASHP market through the MN ASHP Collaborative, the Midwest ASHP Collaborative, and the numerous research projects that have already been conducted by CEE and other firms on the ASHP market.

Research goals

This market characterization report describes key insights to inform market support strategies. The primary research objectives include:

- Uncover customer, contractor, distributor, and manufacturer baseline awareness and perceptions.
- Understand the value proposition for customers and market actors.
- Reveal most salient market barriers and opportunities that can be leveraged by the ETA program.
- Create recommendations for the ASHP initiative for the next 5 years.

[1] This estimate includes homes that also have CAC.

Methodology

Literature review

In this market characterization, the primary means of assessing the state of the market was a literature review thanks to the robust and current research assessing the ASHP supply chain as well as customer awareness. There are two primary reports referenced in this Market Characterization report:

- **Investigation of Air Source Heat Pumps as a Replacement of Central Air Conditioning**, a Conservation Applied Research and Development (CARD) grant project funded by the MN Department of Commerce, Division of Energy Resources, conducted by Center for Energy and Environment, and published in 2022. This study focused on centrally ducted heat pumps as replacements for centrally ducted air conditioners in homes with forced air furnaces. Insights from the supply chain are focused on this application type. This source is referred to in this report as the "2022 CEE AC Replacement CARD Study."
- **Understanding Market Barriers and Opportunities for Cold Climate Air Source Heat Pumps in Residential Households**, a Conservation Applied Research and Development Grant project funded by the MN Department of Commerce, Division of Energy Resources, conducted by Cadmus, and published in 2020. This study focused on market perceptions and barriers around all residential application types but focused on cold climate ASHP technology. This source is referred to in this report as the "2020 Cadmus Cold-Climate ASHP Study."

Additional sources were considered where applicable and are cited throughout.

Contractor interviews

At the beginning of this market characterization, we identified a gap in broad understanding of contractor attitudes and opportunities for increased ASHP adoption. Previous studies focused only on contractors with ASHP experience, and we are interested in perspectives from the full spectrum of HVAC contractors, including those without ASHP experience, given they will be included in market support strategies of the initiative. Thus, in spring 2023, CEE conducted semi-structured phone interviews with HVAC contractors across the state. Through this research we hoped to create a current baseline of awareness and attitudes of the broader contractor pool, including those who did not have prior experience with ASHPs.

Our sample list was derived from the full list of mechanical contractors licensed in the state of Minnesota from the Department of Commerce. Overall, 314 potential respondents were contacted, and 18 interviews were conducted, yielding a response rate of 6%. While we contacted a large number of contractors, interviews were mainly conducted between the end of May and mid-June, which unfortunately saw above 90-degree temperatures, advancing quickly into cooling season and making contractors less available. This limited participation. With just 18 responses, findings cannot be generalized to the full population of contractors.

Therefore, findings should be interpreted with caution as a small number of participants can sway results, especially when considering or comparing percentages. Though a small sample

size, percentages are included for ease of understanding, and the number of respondents is included next to all figure or table percentages for consideration. We anticipate future research will include a broader set of respondents and can bolster current understandings. While our response rate was not as high as hoped, this effort did include contractors with a range of experience and still yields useful insights.

It should also be noted that this survey included questions about both ductless and ducted ASHP technology and did not often differentiate between these two types of ASHPs.

Throughout this market characterization report, contractor interviews are often referred to as "our most recent contractor interviews" or a similar phrase, as this is the primary source document for these interviews. For more information about the contractor interview methodology and detailed research findings, please see Appendix A.

MN ASHP Collaborative expert insight

The MN ASHP Collaborative launched in 2019 and is a joint effort between CEE and Minnesota utilities. The goal of the ASHP Collaborative is to make heat pumps the first choice for contractors and consumers when upgrading their heating and cooling systems. Collaborative staff have engaged with homeowners, performed contractor education, and worked with distributors and manufacturers to capture key barriers and opportunities. Key insights from these program staff are woven through the report as appropriate and when other sources were unavailable. In particular, the path to purchase, market actor roles, and key opportunities sections were largely derived from their insights.

OVERVIEW OF TECHNOLOGY

A heat pump is a heating and air conditioning system that uses the vapor compression cycle with refrigerant to heat or cool a home. Using this cycle, heat pumps work by transferring energy between the outdoors and inside the home. Unlike CACs, heat pumps can reverse the direction of the refrigerant flow to provide both heating and cooling. This process becomes more difficult when there is less heat to be extracted from the air outside, thereby decreasing system efficiency and heating capacity in cold climate conditions. This has historically presented a challenge to the viability of ASHPs in cold climates, although more recent technology developments have improved the ability of modern products to extract heat from cold winter air. Now, ASHPs can move heat well below zero and offer significant energy efficiency and GHG emissions reduction opportunities.

There are two main types of ASHPs in common use: ducted systems, which are primarily unitary and serve the whole home through ductwork (but can also include short-run ducted systems

that provide zonal heating and cooling), and ductless[2] heat pumps. Ducted systems are appropriate for homes that have existing forced air heating and cooling systems. They can replace a central air conditioning (CAC) unit to provide cooling as well as heating. Ductless systems couple an outdoor unit with one or more indoor "heads" that distribute heating and cooling to individual zones or rooms within a home — multiple heads would be needed to serve an entire building. The industry continues to innovate with new features, configurations, and performance improvements. Figure 1 shows what common ASHP systems look like.

Figure 1. Exterior and interior equipment of ducted (left) and ductless ASHP (right)

Cold-climate ASHPs

Research conducted by CEE and others demonstrated that while the efficiency and capacity of older ASHPs does drop significantly for outdoor temperatures below 40°F, the newest generation of ASHPs can operate down to -20°F, and in moderate temperatures, these technologies are more than three times as efficient as standard electric heating systems (especially ductless mini splits).[3] The improved performance of this newer generation of ASHPs is attributed to the addition of an inverter-driven compressor and updates to the refrigerant, which make the systems better suited for cold-climate heating. The inverter-driven compressor allows the compressor speed to modulate based on the needs of the home. Capacity can therefore be decreased in milder heating or cooling conditions and increased when home heating and cooling needs are largest, including during periods of colder outdoor air temperatures.

This new generation of the technology is often referred to as cold-climate ASHPs. Both ductless and ducted ASHP product lines can have this cold-climate functionality. Most major manufacturers carry a cold-climate ASHP product line. The Northeast Energy Efficiency

[2] Ductless units are often referred to as mini-splits. However, the line between ducted and ductless side discharge-style compressors (i.e., mini-splits) is now blurred, and so we refer to these units as ductless mini-splits or ductless ASHPs throughout this report.

[3] CEE research encompassing ducted ASHPs recorded heat transfer occurring as low as -21°F. CEE, "Cold Climate Air Source Heat Pump Field Assessment" (2017). Supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development program. Available here.

Partnerships (NEEP), Northwest Energy Efficiency Alliance (NEEA), and the MN ASHP Collaborative, each define cold-climate ASHPs as having inverter-driven technology. Additionally, the NEEP Qualified Products List (QPL) rates a piece of equipment as cold climate if the coefficient of performance (COP) is 1.75 at 5°F.[4]

CEE field research in Minnesota found that cold-climate ASHPs performed to their rated specifications for both system capacity and efficiency — coefficient of performance (COP) or HSPF.[5] With proper sizing, installation, and integration with back-up heating systems, cold-climate ASHPs are an attractive heating system retrofit in housing with electric or propane heating. Further, CEE research showed that cold-climate ductless mini-splits can reduce energy use and cost by more than 50% when replacing electric resistance heat, and ducted cold-climate ASHPs can reduce energy use by ~60% and cost by ~40% when displacing propane heating.

In providing an opportunity to electrify some of the heating load in homes with existing natural gas or propane systems, ASHPs can also provide a greenhouse gas (GHG) emissions reduction opportunity over the lifetime of the equipment. This exact opportunity depends on the electric grid, as the GHG emissions of using electricity for heating compared to gas or propane depends on how that electricity is generated. The displacement of fossil-fuel heating with efficient ASHPs will result in greater GHG reduction with a transition to clean electricity generation, such as the goal set in Minnesota's recent carbon-free electricity standard.[6]

CURRENT MARKET STATE

To craft an effective and sound market strategy, the ETA team requires clear and specific insights on the state of the market and specific challenges and opportunities that exist within the Minnesota marketplace.

Market definition and initiative focus

Currently, Minnesotans heat and cool their homes with a variety of technologies and use a multitude of fuel types. However, the most common fuel types are natural gas (68% of homes), propane (15% of homes), and electric resistance heat (10% of homes). ASHPs can augment, displace, or replace all three of these most common fuel types. More discussion of baseline technologies and emerging competing technologies can be found in Appendix B.

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[4] The COP is the ratio of energy input to energy output. For example, a COP of 1.75 indicates that 75% more energy is produced by the system in heating energy than goes into the system in terms of electricity. The fact that the COP can be greater than 1.0 (or 100% efficiency) is due to ASHPs not directly heating the air, but rather moving it from one place to another via the vapor-compression cycle.

[5] CEE (2017): "Inverter-driven cold climate ASHPs are capable of operating at very cold temperatures. The monitored performance of the heat pumps systems verify that their installed performance is in line with the manufacturer performance specifications."

[6] MN Department of Commerce, "Governor Walz Signs Bill Moving Minnesota to 100 Percent Clean Energy by 2040" (2023). Available here.

As noted, ASHPs can be ducted or ductless; in other words, they can provide space conditioning through existing ductwork or provide zoned space conditioning. Given the variety of applications and product features, it is important to define the scope of the initiative. Because of the large potential of the natural gas market and a more challenging value proposition, the initiative plans to focus on residential ducted ASHPs for homes heated with natural gas or propane heated furnaces. Thus, for this market characterization report, we were most interested in understanding the market for residential ducted ASHPs, with a particular interest in ASHPs as a replacement for central air conditioners (CACs). While this is a focus, some of the research draws in perspectives about both ducted and ductless models, and they are not always distinguished in the research findings. Wherever possible, we have focused on research findings that are appropriate for this application type.

Path-to-purchase

Traditional pathway

Understanding how the product flows through market actors to the end-use customer highlights where there are barriers, opportunities, or leverage points that can be harnessed by the ETA initiative. Based on the research listed above and the firsthand experience of the MN ASHP Collaborative team, ASHP technology primarily follows the standard HVAC market path-to-purchase, flowing from the manufacturer to distributor then through a contractor to the customer as highlighted in (Figure 2). As discussed in the manufacturer and distributor perceptions of the 2022 CEE AC Replacement CARD Study, there is buy-in for ASHP technology. Contractors and customers still embody the largest barriers and friction points related to increasing adoption of the technology. Additionally, much of the CAC market, the primary focus of the initiative, is driven by emergency replacements. Meaning, existing CAC units either fail at end of life or have significant malfunction and that motivates replacement. Through experience with customers in the MN ASHP Collaborative, we've observed how this emergency replacement scenario strains the purchasing process whereby customers may have less time to consider alternatives and may be more price sensitive without the ability to plan and save for the replacement, and contractors may be more likely to stick with the status quo. There are additional and less common paths-to-purchase through big box retail and online retail that should be tracked and better understood in future research. These are not represented in the figure below as the full pathway is not as well understood.

Figure 2. ASHP traditional path-to-purchase

Big box retail and online DIY

In addition to the traditional pathway listed above, ASHP products are sold through big box retail and online retail.[7] In big box retail sales, ASHPs are displayed and connected directly with an installation contractor for the bid and installation process. Online retail offers options for homeowners to purchase heat pumps directly and perform a self-installation. These are quick-connect refrigerant systems that allow homeowners to perform the installation without a refrigerant handler's license. This is an uncommon path for most customers and could lead to significant customer challenges if this pathway grows in the market. Challenges include system sizing and design based on limited homeowner knowledge, poor installation due to lack of experience, and greater risk of refrigerant leakage, which cuts into the GHG reduction benefits offered by this product.[8] This option is less expensive than purchasing through the traditional HVAC supply chain but comes with many risks and challenges for the consumer based on knowledge and skill level.

Both non-traditional pathways should be the subject of future research to understand current market share and opportunities to increase adoption.

Market actor roles

As described in the path-to-purchase, various market actors play key roles. This table describes market actors that are in the traditional HVAC market, the primary focus of this initiative, and additional market actors that are not the primary focus of this initiative (retailers and builders). Each market actor is described in more detail in Table 1 below.

[7] NEEA, "Northwest Ductless Heat Pump Initiative: Market Progress Evaluation Report 6" (January 2018). Page 39. Available here.

[8] Refrigerants have a global warming potential hundreds to thousands times more than a similar amount of carbon dioxide. "EPA regulations…under…the Clean Air Act require that technicians who maintain, service, repair, or dispose of equipment that could release refrigerants into the atmosphere must be certified." U.S. Environmental Protection Agency, "Section 608 Technician Certification Requirements." Available here.

Table 1. Market actor roles and key characteristics

Market Actor	Key Characteristics and Roles
Manufacturers	■ Includes both traditional North American unitary manufacturers (Carrier, Lennox, Trane, etc.) as well as primary ASHP manufacturers (Daikin, Fujitsu, Mitsubishi, etc.). ■ Provide marketing support and contractor/distributor training resources. ■ Are directly responsible for the development and availability of product.
Distributors	■ Order, warehouse, and sell product to HVAC contractors or "dealers." ■ Provide HVAC contractor training, including in-person training in spring/fall and ongoing, on-demand training modules. ■ Provide technical support and troubleshooting for contractors. ■ Sometimes provides sales and marketing support to contractors.
Contractors	■ Depending on the size of the contractor company, there are numerous distinct audience types that benefit from technology support and information. These staff include owners, managers, sales staff, or specifiers, installers, and customer service representatives. ■ Bid and sell customers on HVAC solutions. ■ Design and install systems in homes. ■ Provide customer education and follow-up support.
Retailers	■ Some retailers promote ASHPs online and through kiosks in big box stores where customers can learn about the technology and engage with an installation contractor. ■ Examples of big box stores with these opportunities include Costco and The Home Depot, and each promote specific brand and installation services. ■ While most products require a contractor installation, retailers can also promote products directly to consumers for do-it-yourself (DIY) installation with a pre-charged refrigerant line set. An example of this product includes Mr. Cool, which most commonly sells ductless products in this category. ■ More information is needed about retail processes, but we anticipate this is a smaller volume of sales.
Builders	■ Specifies HVAC design and product in residential new construction, both single-family and small multifamily (duplex, triplex, and quadplex homes). ■ Oversees HVAC subcontractors' installations. ■ There are differences in motivation, opportunities, barriers, and scale for national production builders and small/local custom builders.

BASELINE MARKET PERCEPTIONS

This section summarizes perceptions regarding ASHP technology across all audiences of the path-to-purchase and across the supply chain including customers, contractors, distributors, and manufacturers.

Customer perspectives

Customer interest in and demand for ASHPs is a key driver for ASHP adoption. The following section highlights customer perceptions and value propositions.

Homeowners lack awareness of ASHP technology, but utilities and other key sources could be trusted messengers

The 2020 Cadmus Cold-Climate ASHP Study surveyed over 942 homeowners in Minnesota to gauge attitudes around ASHP technologies. From their study, only 38% of respondents were aware of *ductless* ASHPs by name or photo, and 46% of respondents recognized "*ducted or central ASHP*" by name or photo (pg. 48). This level of awareness was corroborated by the 2022 CEE AC Replacement CARD Study that surveyed 438 homeowners and found that only 44% of customers had heard of heat pumps as they relate to heating and air conditioning (pg. 34). Additionally, 61% did not know anyone personally who had an ASHP in their HVAC system (pg. 34). This indicates a large growth opportunity for increasing customer familiarity with ASHP technology.

In the AC replacement CARD study, respondents were asked if they look for information to help improve the comfort or energy efficiency of their home. For those who said they sought out information (35%), they looked to online searches and utility-provided information (both websites and information sent directly from utilities) as the most popular resources. When asked about the credibility of sources for selecting air conditioning systems, homeowners listed online searches, utilities, contractors, consumer reports, and friends/family as credible resources. Government information, independent third-party sources, and nonprofits were not seen as top resources (CARD report Appendix).

Homeowners believe in ASHP cooling capabilities but are satisfied with their current cooling systems and operate in a replace-on-fail market

In the 2020 Cadmus Cold-Climate ASHP Study, of those who were aware of ASHP technology, most agreed that they can provide energy efficient heating in cold weather, keep homes warm and comfortable in cold weather, and improve home comfort (73–74%; pg. 50). More agreed that heat pumps can effectively cool a home in hot weather (82%; pg. 50). Given this difference, cooling could be capitalized on to build awareness and focus marketing. Additionally, of the 20 ASHP owners who responded to the survey, 15 used ASHPs as their primary cooling system,

compared to only two who used it solely as their primary heating system, and three who used ASHPs for both, indicating that cooling is a favored capability (pg. 54).

This emphasis on cooling was highlighted by the 2022 CEE AC Replacement CARD Study that found 57% of respondents would be likely to consider ASHP technology as an alternative to a traditional CAC (pg. 35). However, customers were generally happy with their current system and not planning to replace it in the next three years, though some homeowners did show interest in upgrading to a new and better technology, lowering operating costs, zoning capabilities, more consistent temperatures throughout the home, and reducing environmental impact.

The strongest motivator for considering a new CAC system was when their current CAC failed (65% ranked this as their primary motivation, 77% ranked it as one of their top five motivations, pg. 29 & Appendix), followed by if their current CAC had ongoing problems (32% ranked it as a secondary motivation, 58% ranked it as one of their top five; pg. 29 & Appendix). This suggests that while people are open to the idea of ASHPs for cooling, the constraints of the replace-on-fail market likely drive replacement decisions (i.e., needing immediately available products that contractors can install quickly).

Heating capability skepticism remains among a small amount of homeowners

Additionally, despite general agreement on functional capabilities, the 2020 Cadmus Cold-Climate ASHP Study indicated that there is still some skepticism around cold-climate heating functionality, though this was minimal with 9% disagreeing that ASHPs could keep a home warm and comfortable in cold weather (pg. 49). The 2022 CEE AC Replacement CARD Study also indicated that homeowners need to know that the equipment will work in our climate (pg. 26).

Perceptions vary by geography, heating type, and demographics

There were also differences in attitudes from the 2020 Cadmus Cold-Climate ASHP Study around functionality based on geography, heating type, and demographics. Rural respondents were more likely to be aware of ducted ASHPs; respondents with non-ducted heating systems were more likely to be aware of ductless models and more likely to accept cold-climate heating capabilities; and respondents with college degrees were more likely to believe that ASHPs provided energy efficient heating in cold weather (pg. 48–49).

Customers describe performance, equipment costs, and operating costs as key decision-making factors

The 2022 CEE AC Replacement CARD Study found that cooling performance, cost of the equipment, and operating costs were the most important attributes considered in the purchase of a new CAC (72–80% of respondents said they were very important with scores of 8-10 on a scale of importance; CARD Appendix). These were the same highest scoring attributes both

among people who had recently purchased a CAC and those who were considering a CAC upgrade but had not yet purchased a system (referred to as *intenders*), indicating a consistency with performance and cost/savings being key to the value proposition.

Though they were less important than costs and performance, the broader context of the replace-on-fail market and decarbonization trends were also apparent when considering decision-making factors. Over half of recent purchasers and intenders indicated that the speed of getting a new system installed was very important for consideration (score of 8-10 out of 10 in importance), highlighting the need for quick availability of products. There was also a smaller subset of customers who are environmentally driven and are interested in switching to reduce their environmental impact and carbon footprint (42% of recent purchasers and 44% of intending purchasers selected it as a very important for considering a new AC system – score of 8-10 out of 10 - CARD Appendix).

Energy efficiency is also important

Energy efficiency was also key, coming in as the fourth most highly rated attribute in both recent purchasers and intenders groups in the 2022 CEE AC Replacement CARD Study. Additionally, the CARD Study asked if recent purchasers had been offered a high-efficiency option, and if so, if they purchased it. Of those who said they had been offered a high-efficiency option, the vast majority said they had purchased it (88% pg. 32), indicating this is a salient preference when offered.

Energy efficiency was also the top attribute for compelling customers to want to purchase either a ductless or ducted ASHP in the 2020 Cadmus Cold-Climate ASHP Study. However, the more specific temperature rating (certified to provide efficient heating down to 5°F, while most can operate down to -13°F or lower) was not as compelling for ducted models. The idea of using the ducted model as a supplement to their existing furnace was, however, a top attribute.

Costs may be prohibitive

As noted, costs are very important to consumers, and contractors indicated that high upfront costs may be an issue. The 2022 CEE AC Replacement CARD Study also noted that higher product costs make it harder to craft compelling customer value propositions as distributors indicated that ASHPs can cost 50% more or higher than baseline CACs, though cost varies (CEE pg. 38).

The willingness-to-pay portion of the 2022 CEE AC Replacement CARD Study also indicated this cost sensitivity. Over half of recent purchasers (55%) were willing to pay more for lower operating costs with a 15% premium on average (pg. 34). When questioned more on dollar amounts, 45% were likely to spend up to $500 to reduce energy costs of their heating and CAC systems in the next two years, but only 20% said they were likely to spend over $1000. Customers also expected a six-year payback on average (pg. 30 & 34).

Incentives can help reduce costs and increase value proposition

To reduce the cost burden and make the value proposition more attractive, rebates and incentives can help. The 2020 Cadmus Cold-Climate ASHP Study indicated that most potential customers were unlikely to convert their current systems to ductless or ducted ASHPs with no incentive, or low incentives. However as incentive amounts increased, more than half were somewhat or very likely to convert their systems for an incentive amount around 25% of the system cost or between a $900 to $1000 incentive depending on whether the system was ductless or ducted (pg. 64–65). The 2022 CEE AC Replacement CARD Study also suggested that rebates and financing can be important tools for customers (pg. 26), and contractors indicated rebates can make ASHPs more attractive (pg. 36).

Manufacturer and distributor perspectives

Manufacturers and distributors create the product and help get it into the hands of contractors and customers. As such, their efforts and opinions can greatly influence the market. Our most recent data collection effort did not include interviews with these two key actor types; however, both the 2020 Cold-Climate ASHP Cadmus report and 2022 CEE AC Replacement CARD Study conducted interviews with these groups.

More ductless options are currently available, but the opportunity for centrally ducted dual fuel is attractive

In the 2022 CEE AC Replacement CARD study, conversations with both distributors and manufacturers revealed that marketing and sales focused on ductless heat pump models. Manufacturers indicated they were planning to ramp up ducted offerings and distributors indicated a push from the energy industry and movement toward electrification would increase products offered in this category. (pg. 37–38)

Lack of awareness and familiarity by customers and contractors is a perceived issue

Both manufacturers and distributors in the 2022 CEE AC Replacement CARD study noted that a lack of awareness of ASHP technology is likely a key barrier for both customers and contractors. Distributors mentioned that customers have low awareness and interest, and therefore contractors must spend more time selling the product, which can slow down sales, making it less attractive for contractors. Manufacturers noted that customers may have questions or concerns about ASHP technology that contractors cannot address as they are both less familiar with the technology. They also noted that there may be negative perceptions of ASHPs related to prior experiences and lack of awareness around product developments and improvements. Finally, manufacturers discussed that contractors' limited ASHP experience may cause difficulty in properly sizing the system or offering the product to the potential customer. (pg. 37–38)

Manufacturers and distributors indicate some skepticism among contractors around cold-climate performance

The 2020 Cadmus Cold-Climate ASHP Study involved three manufacturers, who all believed their cold-climate ASHP technology would work well for Minnesota — however, they all felt there was some distrust among contractors that the products could perform well in cold climates. Distributors also highlighted this potential skepticism from contractors, indicating that contractor uncertainty can influence customer uncertainty. All participating distributors were familiar with cold-climate ASHPs and most generally felt contractor and customer experiences with cold-climate ASHPs in MN were positive.

Distributors felt competitive advantage and innovative distinction could be a selling point for bringing more distributors and contractors along

In the 2022 CEE AC Replacement CARD Study, distributors noted that being the lead innovator and providing innovative services could be a positive benefit for both contractors and distributors (pg. 37)

Manufacturers and distributors indicated additional customer benefits, including fuel choice and flexibility

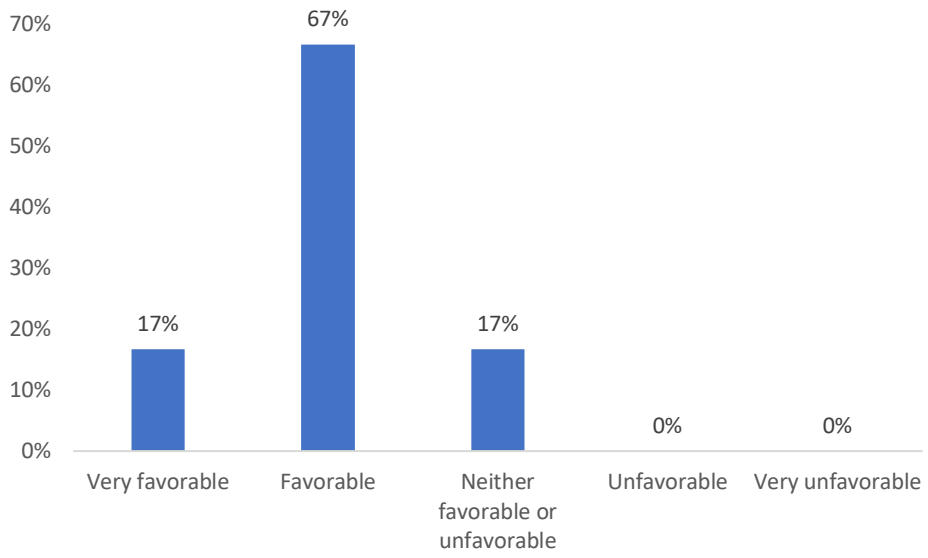
Both distributors and manufacturers with the 2022 CEE AC replacement CARD study noted that dual fuel gas-furnace options have some distinct benefits for customers. The ability to retain a natural gas furnace and switch between electricity and gas can help homeowners use ASHPs when they are most cost-effective and maintain peace of mind since they have multiple fuel sources and familiarity with a natural gas backup system. The heating and cooling capabilities can be especially useful for shoulder seasons as well. Distributors also noted reduced environmental impacts and that ASHPs are often a higher quality product that may be quieter, have a longer life, have better dehumidification, etc. (pg. 37–38)

Contractor perspectives

Contractors view ASHP technology favorably, but are skeptical of heating performance

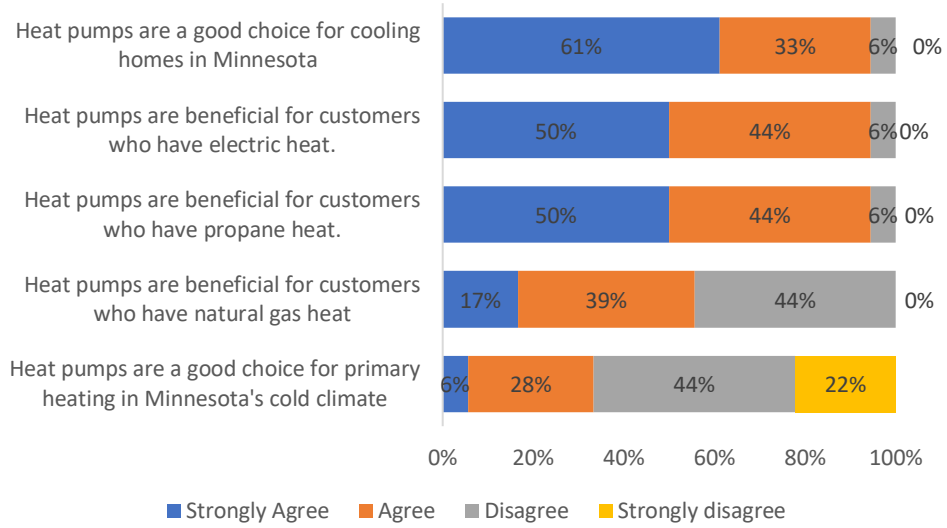
With our recent ASHP contractor survey, most contractors indicated they had a favorable opinion of heat pump technology (83%; Figure 3). When asked why they held that opinion, three or more indicated ASHPs were higher efficiency, decreased fossil fuel use, had advanced technologically, and were good for warmer areas or times of the year.

Figure 3. General opinion of heat pumps (N=17)



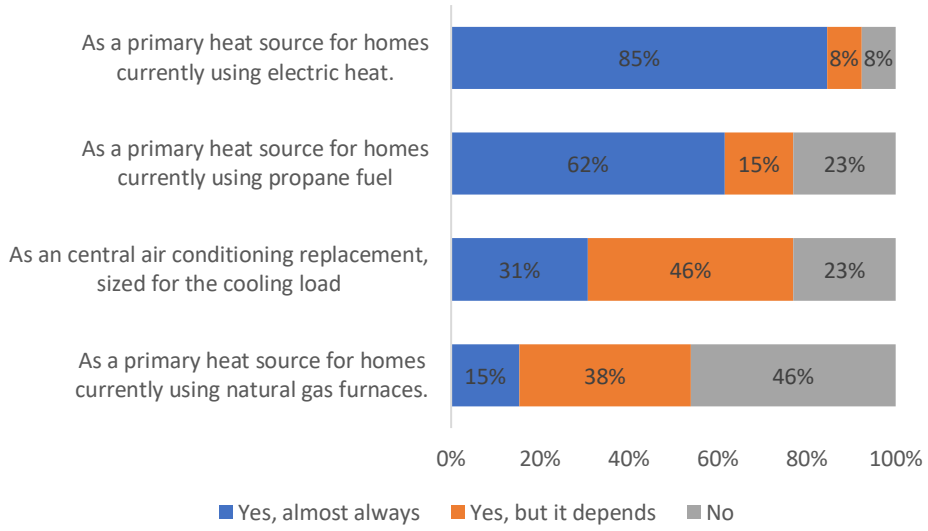
Despite the favorable general opinion, most felt that heat pumps were not a good choice for primary heating in Minnesota's cold climate (Figure 4). However, the majority thought they were a good choice for cooling homes and beneficial for customers with propane and electric heating. Responses were more mixed on customers with natural gas heated homes.

Figure 4. Agreement with specific applications for ASHPs (N=18)



Similarly, we asked those who had experience installing at least a few ASHPs to weigh in on when they would recommend ASHPs. The majority (85%) said they would almost always recommend them as a primary heat source for people currently using electric heat (Figure 5). Most (62%) would also almost always recommend them for homes using propane, and only 15% would almost always recommend them for homes using natural gas furnaces.

Figure 5. Would you recommend ASHPS for the following circumstances? (N=13)



Additionally, the 2020 Cadmus Cold-Climate ASHP Study found that low-volume contractors were less likely to promote standard ASHPs, citing that ASHPs will not save customers money, cannot meet winter heating needs, and require more maintenance (pg. 45).

The 2020 Cadmus Cold-Climate ASHP Study also found that all nine high-volume ASHP contractors (those who installed five or more ASHPs in the past year) were aware of cold-climate heat pump options, most held generally positive views of the technology, and all promoted cold-climate ASHPs (pg. 45). However only one of five low-volume contractors was aware of cold-climate heat pumps, thus indicating a gap with awareness of cold climate applicable products (pg. 45).

Mixed messages on cooling – contractors believe ASHPs are a good choice, but do not always recommend them

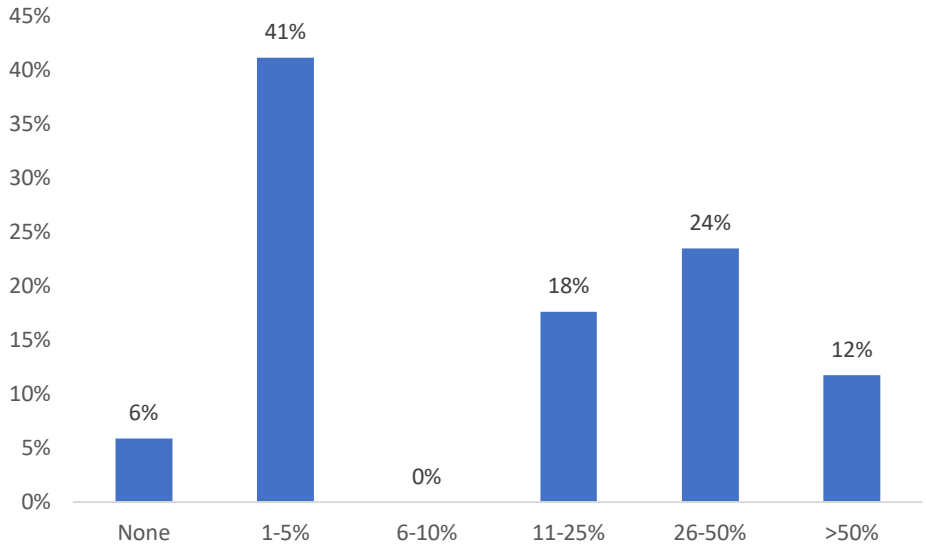
Although 94% of contractors in our recent survey felt that heat pumps were a good choice for cooling homes in Minnesota, responses were more mixed around CAC replacement with 31% saying they would almost always recommend them and 23% saying they would not recommend them for CAC replacement sized for cooling.

From the 2022 CEE AC Replacement Study, 83% of contractors who installed heat pumps said they had recommended a ducted ASHP when replacing a furnace or CAC**.** However, they discussed specific qualifiers and situations in which they would make those recommendations, including when a customer's primary heat source is propane and when rebates help ASHPs achieve cost parity with CAC. They indicated high initial costs, high operational costs, and lack of customer interest as reasons they may not recommend ASHPs.

ASHP sales have room to grow

The 2020 Cadmus Cold-Climate ASHP Study found that only three of nine high-volume ASHP contractors (those who installed five or more ASHPs in the previous year) had ASHPs comprise at least half of their HVAC sales. Similarly, the recent CEE contractor survey indicated that only 12% of respondents had ASHPs make up >50% of their sales, while ASHPs only made up 1–5% of sales for 41% of respondents (Figure 6).

Figure 6. What percentage of your current sales are from heat pumps? (N=17)



Contractors expect ASHP sales to increase

In our recent survey, most respondents indicated that heat pump sales overall will increase over the next five years (83%), and most felt it would increase a lot (61%). No one felt sales would decrease. When asked to describe why they felt that way, nearly half (8) mentioned incentives or policy, including tax credits, utility rebates, and political motivation, as a key driver for heat pump sales. This indicates that these policies and incentives will likely influence the sales baseline trajectory and that these can be important mechanisms moving forward. At least three respondents also mentioned the following drivers: advancing technology, especially for cold-climate options; increasing gas costs that will make heat pumps more appealing; increasing awareness among various market actors; and climate or environmental motivations. Respondents generally felt that both ductless and ducted sales would increase with some saying ductless may increase faster and others saying the opposite. In general, the application type will dictate the appropriate equipment.

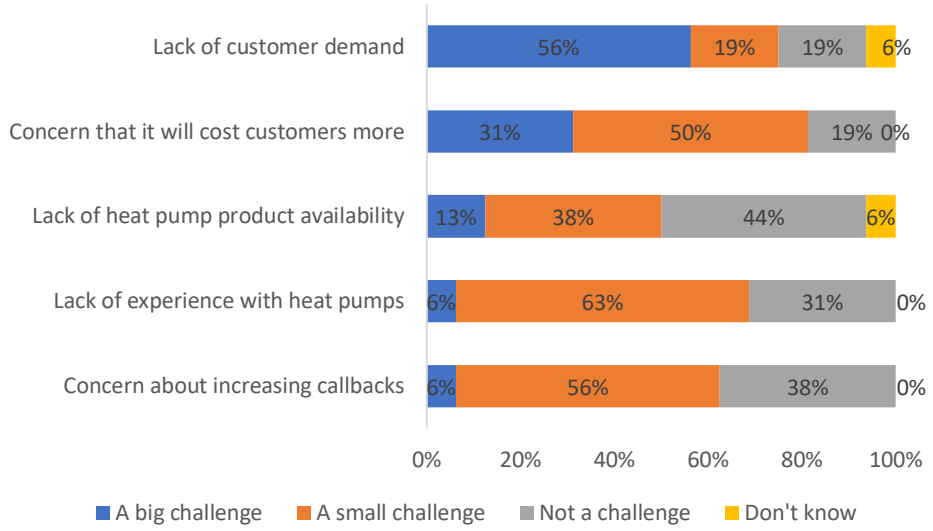
The most recent study indicated a potentially stronger sales increase than in past studies, likely in part due to the incentives and policies currently being rolled out at the federal and state level and concurrent increasing awareness that were not in play for previous research. For comparison, the 2022 CEE AC Replacement Study found that just over half of contractors felt that business would increase for ducted (53%) or ductless ASHPs (60%), compared to 83% of

respondents in this most recent study (ducted and ductless were not distinguished in the most recent study). Contractors similarly noted optimism around ASHP rebates, more customers seeking environmentally friendly options, and rising natural gas prices as potential levers to increase business, but that the high upfront cost was the main reason business may stay the same.

Demand for ASHPs is minimal and a challenge

In the 2022 CEE AC Replacement Study, 43% of contractors reported low or no demand for ducted ASHPs while 33% reported some demand (pg. 36–37). This continues to be a concern as 56% of contractors in our most recent contractor interviews said that lack of customer demand was a big challenge (Figure 7). This was a higher percentage than any other potential challenge.

Figure 7. How big of a challenge are the following for incorporating more heat pumps into your business? (N=16)



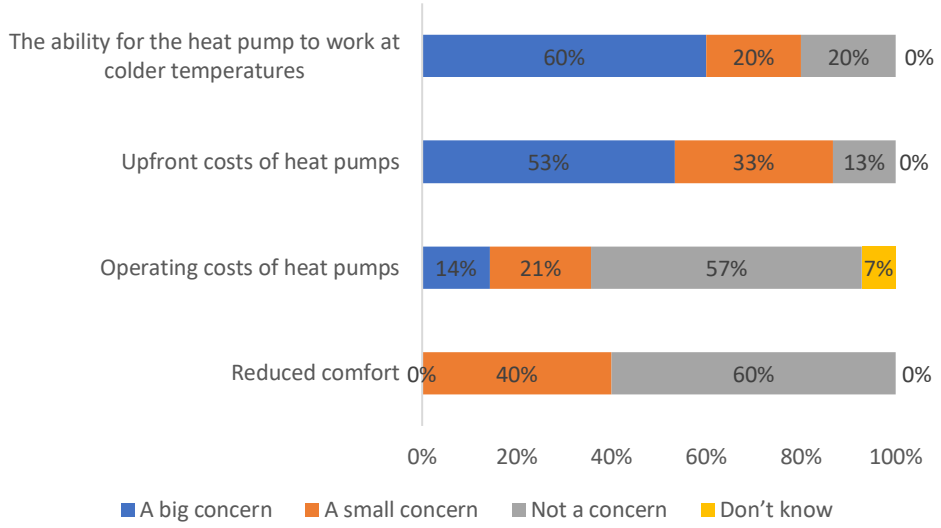
Concern that it will cost customers more was also a notable challenge with 81% indicating it was at least a small challenge. Lack of heat pump availability, lack of experience with heat pumps, and concern about increasing callbacks were all noted as challenges by most respondents, but most felt they were smaller challenges.

From the 2022 CARD AC Replacement Study, most contractors did not report issues with ASHP products or increasing call backs. Per the report, "of those who did report issues, challenges with the defrost cycle, controls, shorter or more error-prone lifespan, and a generally more complicated installation were cited. Issues resulting in customer callbacks were mainly about the low supply air temperatures and confusion with controls" (pg. 37).

Contractors see performance, costs, and the potential for financial savings as key to customer value proposition

Contractors appear to have a good pulse on the value proposition for customers, as their key concerns and benefits for customers in the most recent study align with the key customer decision-making factors from the 2022 CEE AC replacement CARD study. When asked what concerns they felt customers may have, contractors noted the ability for the heat pump to work at colder temperatures and upfront costs were the two biggest concerns (Figure 8). However, contractors perceived operating costs as less of a concern, though that may be a bigger driver as denoted by the 2022 CEE AC Replacement CARD Study.

Figure 8. How big of a concern do you think each of the following are for customers? (N=14-15)



When asked an open-ended question about customer benefits, half of contractors in our recent survey described saving money as a key benefit for customers, more than any other potential benefit. Similar themes of energy savings and incentives also emerged, indicating the financial component is key to the value proposition. This is in line with the 2022 CEE AC Replacement CARD Study where contractors indicated some form of savings (energy or financial) were the top benefit (pg. 37).

In the 2020 Cadmus Cold-Climate ASHP Study, contractors were also asked which customer benefits they promote, and they indicated long-term monetary savings, energy savings, and the ability to cool as well as heat a home (pg. 45).

Contractors described a replace-on-fail dominant market

In the 2022 CEE AC Replacement CARD Study, contractors reported that typically they were replacing equipment once it had failed. They often recommended replacing a furnace if a CAC failed or vice versa (pg. 37).

Baseline product costs

High upfront cost and cost uncertainty

In the Cadmus 2020 and CEE 2022 studies, contractors, builders, and distributors noted higher upfront cost for ASHPs hindered adoption. Distributors reported ASHPs are 50% or greater in cost than baseline cooling equipment (CEE 2022, pg. 38). Upfront cost increases significantly as product advancement and cold-climate capability increases. The table below, from the CEE 2022 Study, shows incremental cost estimates for four different product archetypes (single speed ASHPs, entry level variable speed ASHPs, average performance variable speed ASHPs, and cold-climate variable speed ASHPs). These estimates were derived in two different ways, indicated in Table 2. The "Average Project Bids" column shows averages for CAC-only and full furnace and CAC replacement from installations from the last three years collected through CEE programs. The column labeled "Wholesale-Based" represents CAC-only and full replacement cost estimates utilizing online wholesale pricing with a 40% mark-up to show what costs could look like in a more mature and fully scaled market.

Table 2. Incremental cost estimates for ASHP archetypes (2022 CEE AC Replacement CARD Study)

-	Wholesale-Based [a]		Average Project Bids	
ASHP	**CAC-Only**	**Full [b]**	**CAC-Only**	**Full**
Single speed ASHP	$700	$1,000	$2,000	$4,300
Entry level variable speed ASHP [c]	$2,100	$3,000	$5,000	$6,100
Average variable speed ASHP [c]	$3,500	$4,900	$8,300	$8,800
Cold-climate variable speed ASHP [c]	$4,620	$7,300	$11,100	$10,300

40% margin added to wholesale cost-based estimates

+ $1,000 for sealed vent (where applicable)

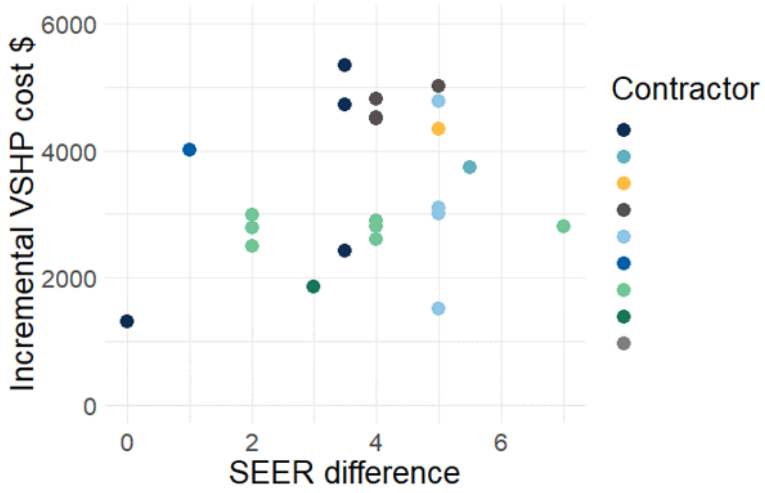
+ $500 for wiring (for multi-stage wiring)

Note: Table 2 is copied directly from the 2022 CEE AC Replacement CARD Study, pg. 41

In addition to high upfront costs, contractor bids can be highly variable for similar equipment. The 2022 CEE AC Replacement CARD Study notes, "Very large variations between bids across the sample set voided any relationship between cost and capacity for equipment sized 2, 2.5, and 3 ton" (pg. 41). This has been observed elsewhere in the Midwest, as well. Figure 9 below, presented at the 2023 ACEEE Hot Air Forum, illustrates a similar lack of correlation between

system costs and system efficiency.[9] This chart displays preliminary findings from a field study of variable speed ASHPs as CAC replacements in the Chicago area. Here, the y-axis is the incremental cost, and the x-axis is the increase in SEER rating, both in comparison to the traditional central CAC alternative. The chart shows no visible pattern between increasing SEER and incremental cost.

Figure 9. Variability in incremental cost of several variable speed heat pumps across bidding contractors in Illinois Incremental cost variability



Note: Figure 9 is copied directly from the presentation for the 2023 ACEEE Hot Air Forum, Variable Speed Heat Pumps For Central Ac Replacement In Illinois

This is an additional source of uncertainty from a customer perspective and is particularly concerning when coupled with the 2022 CEE report's finding that customers typically only receive one bid on their new system installation. The decoupling of system efficiency and capacity from upfront costs adds another layer of opacity and complexity to predicting customer economics, potentially inflating the incremental cost of a system that is already facing barriers to payback.

Incentives

Utility rebates can play a part in mitigating this upfront cost problem. However, in 2023, rebate amounts range from $50 to $2200, and may not fully cover the incremental upfront cost. This variability means that the upfront cost barrier is reduced more for some customers and less for others.

However, there is an unprecedented amount of attention and funding from state and federal sources around electrification and specifically heat pump technology. In 2024, new utility ECO rebates, the Inflation Reduction Act (IRA) tax credit and rebates, as well as new MN state

[9] Ranal Tudawe, "Variable Speed Heat Pumps for Central AC Replacement in Illinois" (2023). Presented at the 2023 ACEEE Hot Air Forum. Available here.

legislation providing additional incentive dollars will help overcome upfront cost barriers. Providing additional context on utility rebates as utilities transition from the Next Generation Energy Act and Conservation Improvement Plan (CIP) regulatory framework[10] to the ECO Act[11] framework that allows for efficient fuel switching, customers with propane and natural gas heat will have access to rebates that incentivize a switch from fossil fuel heating to heating with an ASHP. Since energy savings associated with this fuel switching are larger than historical rebates that only claimed cooling savings offered by heat pumps, the potential rebate amounts could be much larger. Table 3 lists current rebates and planned future rebates aimed to bring down the upfront cost for ASHP technology.

Table 3. Current and planned ASHP incentives in MN

Incentive type	Amount	Qualifications and sources	Timeline
25C federal tax credits - IRA	30% of project costs, up to $2,000	ASHPs must meet the Consortium for Energy Efficiency's highest efficiency tier (not including the advanced tier.	Currently available
CIP Utility rebates	$50–$2,200	Current rebate qualifications are highly varied across utilities, including the federal minimum standard, ENERGY STAR, NEEP, and various other levels based on SEER(2) and/or HSPF(2) ratings.	Currently available
ECO utility rebates	$400–$2,400[12]	Utility rebates are aligned around a few main tiers, including the federal minimum standard, ENERGY STAR v6.1, and the qualifications for the 25C tax credit (see above). Rebate amounts will increase above current levels for some utilities.	Estimated availability in 2024
IRA funded rebates	$2,000–$8,000 (rebate levels depend on household income)	DOE guidance indicates ASHPs must meet ENERGY STAR to qualify for rebates under both the Home Efficiency Rebates Program and the Home Electrification and Appliance Rebates Program.	Estimated availability in 2024

[10] Minnesota Legislature, "Minnesota Session Laws" (2007). Available here.

[11] Minnesota Legislature, "HF 164" (2021). Available here.

[12] $2,400 is referring to Otter Tail's $800/ton ducted cold-climate ASHP rebate, assuming a 3-ton system, which is assumed in savings calculations.

Incentive type	Amount	Qualifications and sources	Timeline
State funded rebates	Up to $4,000 (rebate levels depend on household income)	This program will provide additional funding to homeowners who have qualified for a rebate under one of the above programs funded by the IRA. The bill indicates heat pumps must be “cold-climate rated.”	Estimated availability in 2024
Municipal cost-share programs	$2,000–$2,750	Three municipalities in Minnesota have created cost-share programs for energy efficiency projects. Cold-climate ASHPs qualify for this funding.	Currently available

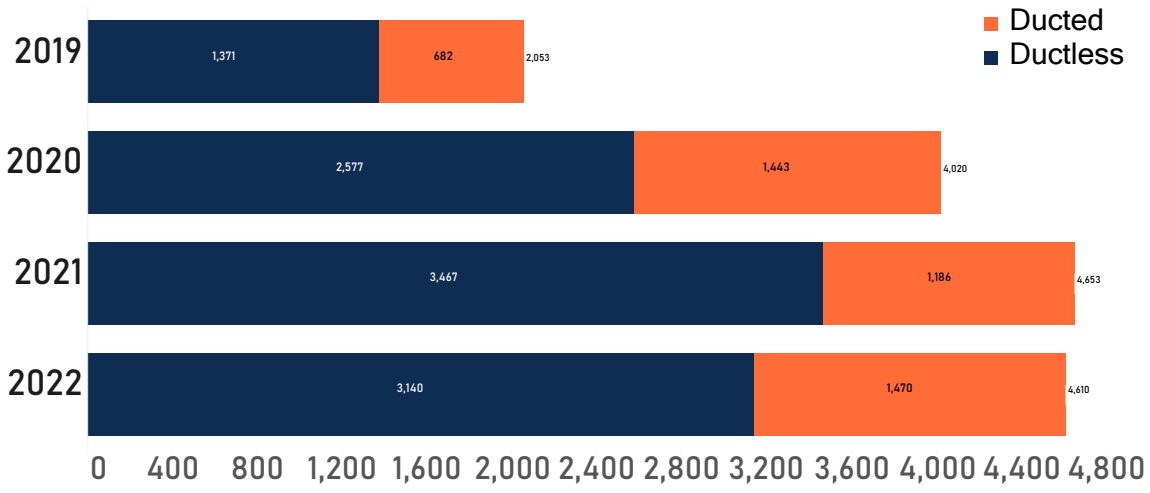
Baseline utility rebated sales

The MN ASHP Collaborative has been collecting utility rebate data since 2019 to understand how rebates sales have trended over time. While this does not provide us with an understanding of the whole market, it does provide insight into volume of rebates sales in the state.

Installation and program participation rates

Despite significant inflation and lack of equipment availability due to supply chain issues, Collaborative members issued about the same number of rebates in 2022 as in 2021 (Figure 10). Several utilities exceeded 2021 program participation. All utilities far exceeded their 2020 rebate numbers. While most rebates issued in 2022 were for ductless systems, the ratio of rebated ducted vs. ductless units increased from 2021 (25% / 75%) to 2022 (32% / 68%).

Figure 10. Characteristics of heat pumps being installed (utility incented)



Operational cost and value proposition

Operational cost and value proposition inconsistency

ASHPs are a highly diverse product category both in the product itself, and how the technology is applied in homes. The value to customers in terms of energy savings, operational cost savings, comfort benefits, and other non-energy benefits is variable and dependent on the home type, how the systems are designed/selected, and the existing fuel type. Value propositions are largely positive from a cost and comfort perspective for homes that have existing electric heat and propane heat as these fuel costs are more expensive and the increase in efficiency can make a big difference. There is also a strong value proposition for customers that do not have air conditioning and are looking to add air conditioning.

The value proposition becomes more challenging in homes that are heated with natural gas.[13] Electricity on average is three to four times more expensive per MMBtu than natural gas (this varies based on rate structures and fluctuations in the natural gas market)[14]. Currently, at standard electric rates, ASHPs have the potential to either increase operational costs, remain cost neutral, or save customer costs. How systems are selected, sized, and installed all impact this outcome. Most importantly, the electric rate is the biggest driver of customer operational cost economics. Electric rates do exist in the state that are interruptible and require a backup fuel source, sometimes referred to as "dual fuel electric rates". These rates can be significantly less expensive than standard electric rates and dramatically change the value proposition for customers. The complexity described above presents a challenge for contractors to acquire the confidence, skill, and knowledge to sell and design systems in a way that has the highest value proposition for customers.

An additional challenge for customers with natural gas heated homes (central forced air furnaces and CAC), which comprises 68% of Minnesota homes (CEE 2022 pg. 21), is that these homeowners are overwhelmingly satisfied with their existing solution. But these homeowners did indicate an interest in upgrading to a new and better technology, lowering operating costs, zoning capabilities, more consistent temperatures throughout the home, and reducing environmental impact (pg. 25 & 27). Over half of customers also noted that they would be willing to pay more for an air conditioning system that offered a lower operational cost, and on average, they would pay 15% more and expect a 6-year payback.

Fuel rate challenges

Expanding into the topic of rates, electric rates are variable across Minnesota utilities, and there are varying rate classes within utilities that have a substantial impact on value proposition. The comparative cost of a unit of energy provided from natural gas against one from the electric grid determines the efficiency required for the heat pump to produce savings. For example, if

[13] MN ASHP Collaborative, "Cost of Heat Comparison Resources." Available here.

[14] CEE, "Normalized Heating Fuel Prices in Minnesota." Available here.

electricity is four times the price of gas, the heat pump must use a quarter of the heating energy or less to lower the customer's overall heating energy bills. In a dual fuel scenario, this relationship means the heat pump can only be used while its efficiency is high enough for this to be true, adding system design complexity and typically limiting heat pump operation to milder winter conditions. The MN ASHP Collaborative has a dashboard[15] that illustrates this impact.

The cost of operating the heat pump system therefore depends on both the system efficiency and the available utility rates. Bills can be reduced by selecting, installing, and operating the heat pump to maximize efficiency, as well as through conducive utility electric rate design. The Midwest ASHP Collaborative published a paper[16] on utility rate design and how rates could be designed in a more beneficial manner for heat pump adoption. Some Minnesota utilities currently have dual fuel, interruptible rates that dramatically lower standard electric rates ($0.07–$0.11 /kWh vs. $0.11–$0.19 /kWh). These rates typically require a separate meter that can add additional upfront costs, but the operational costs are much more favorable. Some utilities, especially cooperatives, cover the cost of this additional expense. Some utilities are pursuing removing the barrier of a separate meter requirement and leveraging AMI metering to achieve more seamless and cost-effective beneficial rates for customers with fewer barriers to entry.

Additionally, according to the 2020 Cadmus Cold-Climate ASHP Study, varying operating costs make it challenging to justify higher upfront costs in homes with natural gas because payback is uncertain or even unfavorable (pg. 112). Many contractors also consider heating economics of ASHPs when considering their viability for customers and this uncertainty can make it challenging for them to have confidence in the product as a heating solution (CEE 2022, pg. 26). Also, as evidenced by Figure 5 above, contractors surveyed in 2023 are hesitant to recommend heat pumps as a heating solution for natural gas heated homes.

Fuel rate opportunities

A key recommendation from CEE's 2022 AC Replacement CARD Study is the approval of rate structures that are more conducive to positive customer bill savings with electrified heating systems. According to this report, "utilities' flexibility to lower rates for natural gas customers who adopt ASHPs is the most impactful lever to accelerate ASHP adoptions in pursuit of state decarbonization goals." This is corroborated with the findings in the 2023 Midwest ASHP Collaborative's rates analysis white paper,[17] which expands on the issue of difficult and uncertain customer bill savings scenarios and advocates for special rate conditions for dual fuel customers from both a utility and customer perspective.

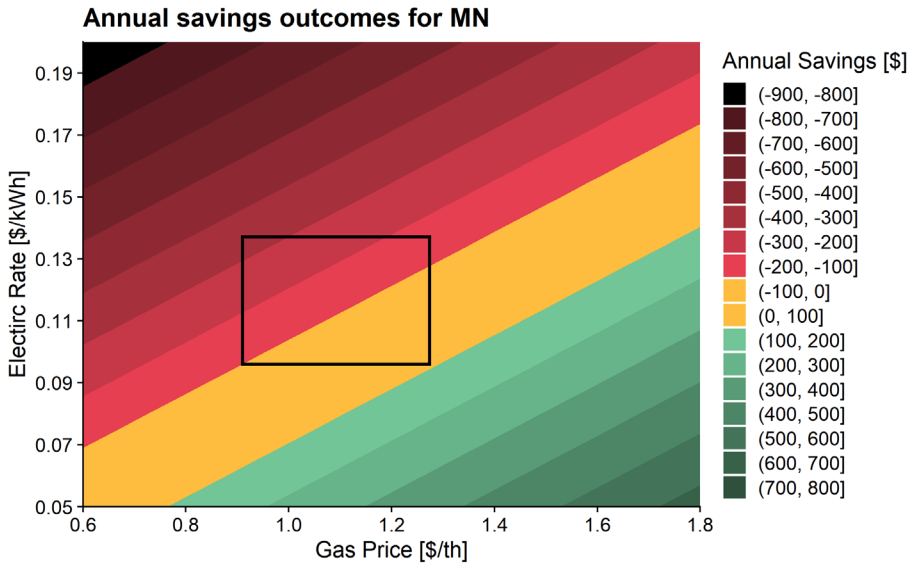
[15] MN ASHP Collaborative, "Cost of Heat Comparison Resources." Available here.

[16] Chidinma Emenike, Ranal Tudawe, Carl Nelson, and Molly Garcia, "Developing Electric Rates for Hybrid Air Source Heat Pumps in the Midwest" (April 2023). Center for Energy and Environment. Available here.

[17] Ibid.

This figure (11) from the Midwest ASHP Collaborative's 2023 white paper on rates displays the annual savings outcomes for a typical single-family home in Minnesota's climate and utility rate landscape. The displayed scenario is the electrification of half the average household's annual heating load (occurring above about 20°F) with a dual fuel cold-climate variable speed ASHP, compared to a baseline 95 AFUE natural gas furnace and SEER 14 central AC.

Figure 11. Contour plot of average home's potential savings outcomes for a range of electric and gas rate combinations in Minnesota



Stripes in red indicate rate combinations where customers would pay more to heat with a heat pump, stripes in yellow are roughly cost neutral, and stripes in green indicate rate structures where customers can save money by switching from natural gas heat to an electric heat pump. The black box illustrates rough ballparks of where standard rates have been in recent years.

Note: Figure 11 is copied directly from Developing Electric Rates for Hybrid Air Source Heat Pumps in the Midwest (pg. 22)

Using this archetypal home and representative replacement and baseline equipment, customers could end up spending $900 more per year on heating or saving $800 a year in the most optimistic scenario, depending on the customer's electric and gas rate combination. Even more variability is introduced when considering different ASHP product options and nuances of the existing home and heating/cooling systems, which could widen this cost differential even further.

Plainly stated, utility rates hinder natural gas contractors and customers (who make up the majority of homeowners in the state) from selecting a heat pump due to concerns of rising energy costs. The research reported in this white paper supports that special utility rates are justified from a ratemaking and grid perspective, can lower barriers to electrification for this customer group, and are necessary to equitably electrify the heating load serving those Minnesotans who experience high energy burdens.

OVERARCHING MARKET BARRIERS AND OPPORTUNITIES

Based on the primary research completed through this study with contractors, the 2020 Cadmus Cold-Climate ASHP Study, the 2022 CEE AC Replacement CARD Study, and internal expertise, the team was able to distill a holistic view of the market and tease out key barriers and opportunities that exist today. The barriers and opportunities identified are wide ranging and exist within the domains of customer, contractor, distributor, manufacturer, utility, policy, and regulation. Some of these barriers and opportunities have already been discussed, and this section serves to synthesize information across different key stakeholder types. Following the key barriers and opportunities section, the recommendations section of the report identifies the key leverage points in the market and provides recommendations for the ASHP Efficient Technology Accelerator initiative.

Barriers

Barriers in this context are defined as systemic or attitudinal challenges that are preventing accelerated adoption of ASHP technologies in Minnesota. Below, we outline the main barriers that surfaced across the body of research.

1. Limited product experience, skepticism of cold-climate performance, and past negative experiences.

Over the past four years, knowledge of ASHPs and positive perceptions have increased among both contractor and customers. However, prior negative experiences, skepticism of ASHP efficacy in cold climates, and limited experiential knowledge of ASHPs still exists in the market.

In the 2020 Cadmus Cold-Climate ASHP Study, this barrier was emphasized, and it was noted that contractors were actively talking customers out of heat pump sales due to lack of confidence in the technology. The primary barrier involved contractors' skepticism around the equipment's ability to perform in Minnesota's climate, specifically below 30°F (Cadmus 2020, pg. 69). In the same study, customers also expressed product performance skepticism.

Contractor research revealed that due to contractors' limited heat pump experience, load calculations, sizing, and design best practices, as well as sales processes, are underdeveloped and are inhibiting market growth. Additionally, manufacturers noted that customers and contractors have had negative experience with prior generations of heat pumps and were not aware of product advancements. (CEE 2022, pg. 38)

Since the 2020 Cadmus Cold-Climate ASHP Study was performed, CEE launched the MN ASHP Collaborative and has developed robust customer and contractor resources. Over the last three years, the Collaborative delivered at least 20 trainings to over 350 installation contractors and supported over 230 customers that reached out directly to the program. With this market characterization and the 2023 contractor survey performed, we see evidence of shifting attitudes in ASHP perceptions.

This barrier has tempered over the past three years, though evidence remains of contractor skepticism and lack of faith in the technology as a heating solution. As noted above, in our most recent survey, all but one contractor (94%) agreed that heat pumps are a good choice for cooling homes in MN, however, only a third of contractors felt that ASHPs are good choice for primary heating in MN's cold climate.

While progress has been made in contractor and customer attitudes around ASHPs, there is still work needed to increase comfort and confidence in the technology as a heating solution.

2. Replace on failure nature of residential HVAC

In the 2022 CEE AC Replacement Study, most customers surveyed indicated their top motivation for replacing their CAC units was upon current equipment failure. This indicates customers are operating in a replace-on-fail market. Contractors also corroborated this sentiment in the same study.

This end-of-life decision making poses challenges to both customers and contractors in the sales and decision-making process. Potential customers indicated wanting to make careful choices and obtain multiple bids, but most customers who actually purchased equipment only received a single bid (CEE 2022, Appendix). The emergency replacement nature of this market creates the following set of circumstances at the point of purchase.

- Customers are without cooling and need to decide quickly to get their system replaced.
- Customers may be under a greater financial constraint due to the unplanned nature of the replacement.
- Contractors may be focused on speed of service rather than an upsell that would add complexity, time, and cost to the process.
- Product availability and stock influences purchasing decision based on the speed of decision making and installation needs.

Based on this market behavior, contractors need to be prepared to design and bid heat pumps in place of CAC, customers need some baseline awareness of heat pumps to be receptive to a heat pump upsell, and product needs to be readily available and in stock.

3. Variable value proposition across application types

Value proposition is defined by the Oxford dictionary as "innovations, services, or features intended to make a product attractive to customers." For residential heating and cooling, according to CEE's 2022 Study, the value proposition for ASHPs comprises upfront cost, operational cost savings potential, and other perceived benefits of the technology that can be unrelated to cost (e.g., new innovative technology, comfort enhancements, advanced controls, and environmental benefits). The formula for value proposition varies by individual customer but the 2022 research shows that, as a trend, customers value the following factors most strongly in their decision making.

- Cooling performance
- Cost of equipment
- Operating costs

- Energy efficiency

(CEE 2022 pg. 30)

As described in preceding sections, the upfront cost of equipment is typically higher for ASHPs, and operating costs for equipment can vary widely based on fuel type. Depending on ultimate upfront cost (including any rebates or incentives) and fuel rates, the value propositions can vary significantly from customer to customer. This inconsistency can be challenging for contractors and customers to navigate.

4. Lack of customer awareness and demand for ASHPs

As indicated by both the 2020 Cadmus Cold-Climate ASHP Study and the 2022 CEE AC Replacement CARD Study, most potential consumers are not aware of ASHPs. This also means there is a lack of customer demand. Additionally, the 2022 CEE AC Replacement CARD Study showed that contractors, distributors, and manufacturers reported low customer awareness and interest as a barrier to adoption. This continues to persist as more contractors in our recent interviews noted that lack of customer demand was a bigger challenge than any other barrier discussed.

Distributors also noted that contractors need to have a more engaging educational sales process to successfully sell heat pumps. This added sales burden could slow down the sales process making heat pumps less attractive to contractors (CEE 2022, pg. 38). This barrier could be mitigated by preparing contractors for this intensive sales process or priming customers with a higher baseline level of awareness.

5. Lack of utility program consistency and stocking

With roughly 175 separate utility territories across Minnesota, rebate program requirements, product specifications, and rebate amounts vary from territory to territory — rebate amounts vary from $50 to $2200.[18] This variability is challenging for distributors to appropriately stock qualified products (CEE 2022, 38). Additionally, from ASHP Collaborative experience we understand this variability is difficult for customers to navigate and for contractors to understand and leverage rebates as selling tools.

In addition to the variability of rebate amount, program requirements and product specifications are also highly variable across programs. To put a finer point on it, distributors reported that it is difficult to plan proper inventory buying patterns because utility program specifications are so variable. Distributors operate in larger territories, so this inconsistency is a barrier to selecting unit types and volume of stock to carry (CEE 2022, pg. 38).

As the state and federal rebates roll out, this will likely spur market shifting and alignment, which should improve this challenging environment.

[18] The MN ASHP Collaborative collates these varying requirements for contractors and customers. Available here.

Opportunities

Opportunities in the context of this market characterization report are defined as leverage points that could accelerate the market more quickly. Based on the research reviewed and the experience of the MN ASHP Collaborative team, the following are key opportunities that could advance the heat pump market at a more rapid pace.

1. Unprecedented federal, state, and utility incentives

As discussed, there is an unprecedented amount of rebate and tax credit program funding from state and federal levels around electrification. Many of these are specifically aimed at supporting heat pump technology, with singular rebate amounts up to $8,000 and the ability to stack some incentives such as the tax credit with other rebates. These incentives are a compelling tool that can increase customer adoption. However, the layers of funding can complicate the process and confuse customers and contractors. This opportunity should be approached with care and caution, and customers and contractors will need tools and resources to successfully leverage these funds.

The potential to braid these funds and move the market faster depends on aligning the various programs to the extent possible to allow for seamless customer and contractor experience. Additionally, product specifications should receive special consideration to ensure that they match the intended outcome of the incentives and that specifications are aligned so that distributors can appropriately stock qualifying products. Additionally, frequent changes to incentive requirements are detrimental to the market as distributors require roughly a 6-month lead time to order and receive product. Thus, market actors need long lead times to adapt to significant program changes.

2. Electric rates optimization and demand response incentives

The value proposition to customers electrifying space heating can improve if either natural gas rates increase or lower electric rates are offered by utilities. Based on research by the Midwest ASHP Collaborative and through cost of heat comparison modeling[19] and engagement by the MN ASHP Collaborative, there are pathways to optimize electric rates for ASHP customers. This ensures operational cost savings are present after the initial investment in the equipment and can help sway customer decision making. This pathway can be achieved through rates that consider the load shape and cost to serve ASHP customers and consider customers who have a secondary fuel source where their electric heat can be interruptible.

This secondary heat source provides an opportunity for utilities to perform price arbitrage by disabling electric heat during times of high wholesale costs. In an electrified future, a secondary

[19] MN ASHP Collaborative, "Cost of Heat Comparison Resources." Available here.

heat source can prevent the need to build additional electrical generation capacity to meet a higher winter peak demand load.[20]

Rate optimization can be achieved by providing technical support to utilities, highlighting the benefit of increased ASHP load (e.g., improved load factor in shoulder seasons), supporting the adoption of these new rates in the public regulatory process, and promoting and socializing approved rates through engagement with HVAC distributors and contractors.

3. Local government climate action and public awareness

Through the MN ASHP Collaborative and efforts by CEE's Communities team's implementation of the Electrify Everything program, we support opportunities to accelerate promotion and adoption of heat pump technology by partnering with local municipalities. Many cities and local governments have climate action plans and funds to promote technologies that mitigate global climate change. ASHPs are already a focus of many cities' action plans and campaigns, and there is opportunity to deepen this engagement and empower cities to have a greater impact with their constituents.

Local governments have an opportunity to increase public awareness of the technology, benefits, and available incentives. As local governments have robust networks for communicating with constituents, they can drive interest and help foster positive word-of-mouth. The ETA initiative should continue engaging with cities and ensure that cities include heat pump campaigns in their sustainability action plans. ETA can also develop and provide an array of tools and resources to help cities increase consumer awareness through campaigns.

4. Broader decarbonization trends

As awareness around global climate change and desire for mitigation continues to increase, various market actors are committing to and looking for ways to achieve decarbonization. These market actors include customers, utilities, governments entities, and manufacturers wishing to have a positive impact and meet ESG requirements. Heat pumps are being recognized as one way help meet those requirements and reduce carbon footprints. Globally, the war in Ukraine and the tenuous reliance on Russian natural gas in Europe is also motivating high growth rates of heat pump sales.[21]

This growth supports heat pump research, development, and deployment by global manufacturers. In the U.S., President Biden invoked the Defense Product Act to support domestic production of electric heat pumps. This allocates $250 million to heat pump production in both the commercial and residential sector.[22]

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[20] CEE, "Decarbonizing Minnesota's Natural Gas End Uses" (2021). Available here.

[21] Yannick Monschauer, Chiara Delmastro, and Rafael Martinez-Gordon, "Global heat pump sales continue double-digit growth" (March 2023). Available here.

[22] U.S. Department of Energy, "Biden-Harris Administration Announce $250 Million to Accelerate Electric Heat Pump Manufacturing Across America" (April 2023). Available here.

In addition, the Inflation Reduction Act provides funding mechanisms for consumers through multiple avenues such as federal tax credits and home energy rebates, and Minnesota passed legislation to add additional incentives.[23] Lastly, the passage of the bipartisan ECO Act in 2021 allows MN electric and gas utilities to support fuel switching when meeting certain requirements.[24] This may allow additional or broader rebates for customers wishing to install ASHPs via utility programs starting in 2024. For example, this regulatory switch enables gas utilities to claim savings and promote heat pump programs. These funding mechanisms will help motivate consumers to choose heat pumps instead of ACs.

Additionally, based on the 2022 CEE AC Replacement CARD Study, manufacturers reported a belief that the market is transitioning away from fossil fuels and their future focus skewed more heavily toward electric fuel sources and energy efficient technologies (CEE 2022, pg. 26).

5. State and federal codes and standards

While codes and standards were not described as a key opportunity in the market research, market transformation theory suggests that codes and standards can be a critical driver of market transformation, especially with a technology like ASHPs that has fewer non-energy benefits but a clear code requirement pathway. ETA thus has an opportunity to codify ASHP technology as standard practice in the Minnesota market by influencing the adoption of efficiency code or standards that would make ASHP technology standard practice.

Minnesota adopts a statewide residential energy code at six-year intervals. Future state code adoption and iterations of the IECC model energy code could contain language that would make ASHPs standard practice. The IECC national model energy code is reviewed and updated on a three-year cycle. Another avenue could include advocacy at a federal level to encourage ASHPs in place of CACs through federal appliance standards. Before implementing a code or a standard change, careful consideration would be given to this process in relation to the measure's maturity in the market, subsequent impacts to customer costs, and funder perspectives on the strategy.

RECOMMENDATIONS

Based on the previous research and ASHP collaborative program experience, the team compiled the following five broad recommendations for the ASHP initiative to consider for the next three to five years.

[23] Minnesota Legislature, "HF 2310" (2023). Available here.

[24] Minnesota Legislature, "HF 164" (2021). Available here.

1. Work to improve upfront cost, operational cost, and overall value proposition for customers

Based on the 2022 CEE AC Replacement CARD Study, homeowners indicated that cooling performance, upfront cost, and operating cost are the most important considerations for purchasing new CAC equipment. These can be barriers in purchasing new equipment and will be critical to overcome for developing a strong value proposition for ASHPs. This is especially true as the research indicated homeowners with natural gas furnaces and CAC systems are happy with their current systems. This can be addressed through highlighting performance in MN climate, offering incentives and financing, and leveraging dual fuel rates to craft a value proposition that would be attractive to customers.

Costs and performance are not the only factors to highlight, however, when developing value propositions. Some homeowners are also motivated to upgrade to new and better technology and a smaller segment is motivated to reduce environmental impact. Distributors also noted the potential value of fuel choice and flexibility and better quality products with additional benefits like better dehumidification or a longer life.

Based on these insights, the initiative should work to clearly define value propositions to customers based on application type (e.g., propane vs. natural gas). This value proposition should include financial benefits including operational cost impacts, available incentives, and additional benefits outside of cost that make the product attractive. These value propositions should be carefully packaged and vetted with MN customers to ensure optimal messaging. Once vetted, these value propositions and messaging should be packaged for contractors, utilities, and the state to leverage in sales and marketing efforts (see recommendation #3 for additional detail on supporting awareness).

2. Support increase of contractor knowledge, comfort, and experience — cultivate heat pump champions

Our recent contractor survey indicates that there are generally favorable opinions about ASHP technology; however, there is still reticence in recommending and installing ASHPs as a primary heat source and for natural gas applications. Per ASHP Collaborative experience, ASHP service offerings are highly variable across companies and geographically across the state.

The program should therefore work to increase contractor knowledge, comfort, and experience with ASHPs, thereby cultivating heat pump champions. The initiative can accomplish this by continuing to offer high-quality training with evolving curriculum to meet contractors on their evolving journey to heat pump expertise. Additionally, the initiative should continue to grow and evolve the preferred contractor network and work with distributors to increase contractor support for ASHPs. The program should continue highlighting and curating a list of most committed contractors and support the development of ASHP business models of participating contractors and non-participating contractors interested in getting more involved with ASHP technology. Lastly, the initiative can increase marketing and sales support for ASHP technologies as new resources and incentives become available.

3. Support increase of customer awareness

Contractors reported that the largest barrier to product adoption from their perspective is the lack of customer awareness and customer demand. If contractors receive signals from the market that customers are either more receptive or actively seeking ASHP technology, this will propel contractor engagement to the next level and trigger a faster pace of market growth.

In addition to the need for more customer awareness as identified through the 2023 contractor survey, there are also some vehicles for increasing customer awareness on the horizon. Those mechanisms include new fuel switching rebates from MN utilities enabled by the ECO Act, the rebates offered at the state level funded by state-specific legislation and the IRA, and tax credits from the IRA. These rebate programs will include customer outreach plans that give MN homeowners more information on ASHPs, which will likely increase interest in the technology.

The ETA initiative can play a valuable role in aligning and strengthening the customer awareness and marketing activities that will unfold in the market. The initiative can lead collaboration and information sharing across utilities, the state, cities, and the supply chain to ensure there is coordination and alignment. Additionally, the initiative should also consider leading the development of customer messaging, informed by MN customers, as well as the creation of tools and resources to support the various ASHP rebate programs and campaigns that will expand over time. These resources could include messaging guidance, ASHP stock photos, and marketing resource templates that other programs can leverage.

4. Leverage decarbonization trends

As highlighted in the opportunities section of this report, there are growing trends around decarbonization that could potentially offer tailwinds in the heat pump market. Local, state, and federal governments are rolling out unprecedented climate policy and funding to support carbon reduction. This provides the opportunity for stackable high dollar incentives to overcome higher upfront product cost, and these efforts can be critical in increasing customer awareness and interest. Through public awareness campaigns, there is an opportunity to create more demand for ASHPs, which will develop the market and solidify contractor experience, interest, and installation quality.

The ASHP initiative should harness this external trend to help drive adoption and awareness of the technology at a faster pace. The program has the following opportunities to leverage decarbonization trends.

- Promote alignment in program design and product specifications across programs at the state, federal, utility, and local government levels.
- Ensure clarity and awareness of available funds at the contractor and customer level so that qualified customers take advantage of all applicable incentives and can braid together multiple rebates, tax credits, and financing sources to make the purchase of ASHPs more feasible, especially for income-qualified customers.
- Provide quality and tested messaging and materials that effectively communicate the value of ASHPs to customers. Provide this consistent messaging to state, utility, and local government programs to increase consumer interest and ensure consistency in

communicating these benefits across all channels to increase impact and mitigate confusion.

- Engage with other national decarbonization programs and efforts to track activities and monitor new and better ways to deploy programmatic elements. Disseminate lessons learned and findings at the local level to ensure that the state, utilities, and local governments deploy the most current program best practices.
- Continue to track and support beneficial policy efforts at the state and federal levels.

5. Codes and Standards Improvements

ASHPs as a beneficial electrification strategy have a challenging value proposition. For customers with existing natural gas or propane furnaces and CAC (roughly 75% of Minnesotans), satisfaction with their existing system is reported to be high and operational costs are relatively low. While there is a near-term influx of incentives that will support the choice of ASHPs and increase familiarity and demand on the part of customers and contractors, there is still a challenge to reach the full saturation and potential of this technology to supplant conventional purchasing decisions.

Given this challenge and the market transformation opportunity, we recommend that the initiative pursue strategies that include state residential code or state or federal appliance standards to propel this technology from the early adopter/early majority phase to a point of market saturation that would indicate the end of market interventions through the ASHP initiative. By supporting the early market with the strategic market supports outlined in this recommendations section, that will create traction and support the feasibility of a code or standard. We recommend exploring different pathways in the first few years of the initiative to determine what code or standard option will be the most viable, resource efficient choice to pursue, and yield the outcome most closely aligned with the goal of this initiative to make ASHPs the new standard in home heating.

Future research

While this report highlights some of the more current research on ASHPs in Minnesota, ongoing research is needed to keep a pulse on a quickly changing market. Research priorities could include:

- Greater insights into the direct-to-customer retail and online retail options, including how they operate and their sales volume
- Ongoing contractor surveys to understand changes with perceptions, sales patterns, incentive structures, barriers, and demand
    - It will be important to include a broad swath of contractors, not just those with ASHP experience, to fully gauge current market dynamics
- Additional customer research, including messaging or segmentation research, to identify appropriate outreach pathways and messages as consumers are generally happy with existing equipment but interested in upgrading for various reasons

APPENDIX A. DETAILED PRIMARY RESEARCH FINDINGS

Introduction

While previous work had been conducted with the 2020 Cadmus Cold-Climate ASHP Study and the 2022 CEE AC Replacement CARD Study, we felt that there were gaps in our market characterization knowledge that could be explored by an additional HVAC contractor survey. Both studies utilized information from contractors who had experience with ASHPs but did not include information from those without ASHP experience. Additionally, while these studies were recent, we felt that significant changes announced with federal and state legislation and incentive structures may have shifted opinions and market configurations.

This primary research effort aimed to serve as a more current baseline of contractors with a range of experience with heat pump technology to gain a broader understanding of perceptions, sales, benefits, challenges, and potential catalysts for installing more ASHPs. While our response rate was not as high as hoped, this effort did include contractors with a range of experience. Additional market characterization work with this broad population should be done in the future and as additional policy and market structures emerge.

Methods and participant characteristics

For market characterization, CEE conducted semi-structured phone interviews with 18 HVAC contractors across the state. Phone interviews were around 15–20 minutes per interview, and contractors were offered a $100 Amazon gift card as a thank you for their time.

Our sample list was derived from the full list of mechanical contractors licensed in the state of Minnesota from the Department of Commerce (2,525 records). Records were then given a geographic code and stratified based on their location in the northern regions of the state, southern regions of the state, or the metro area (as defined by the MN ASHP Collaborative). One hundred contacts were selected from each region to comprise our initial sample. This list often included plumbers and other types of professionals who would not be prioritized, so while these were left on our sample list, they were deprioritized, and other contacts were added with the aid of internet search.

Overall, 314 potential respondents were contacted, with a response rate of 6%.

Limitations

While we contacted a large number of contractors, interviews were largely conducted between the end of May and mid-June, which unfortunately saw above 90-degree temperatures, propelling us quickly into cooling season, and making contractors less available. This limited participation. With just 18 responses, findings cannot be generalized to the full population of contractors. In the future, a target interview timeframe of September/early October or April/early May could yield a higher response rate.

Although we noted a contractor did not have to have experience with heat pumps to participate, it is likely that there may be some selection bias in our results. Most contractors who participated had a favorable opinion of heat pumps, and while that may be reflective of the broader population, we may still be missing those with more negative views.

Additionally, it is important to note that most questions were regarding ASHPs in general, not specific application or product types. This is especially noteworthy in that we did not ask separate questions about ductless heat pumps vs. ducted heat pumps, or specifically about cold-climate products. Opinions may vary about these different products and application types.

General characteristics

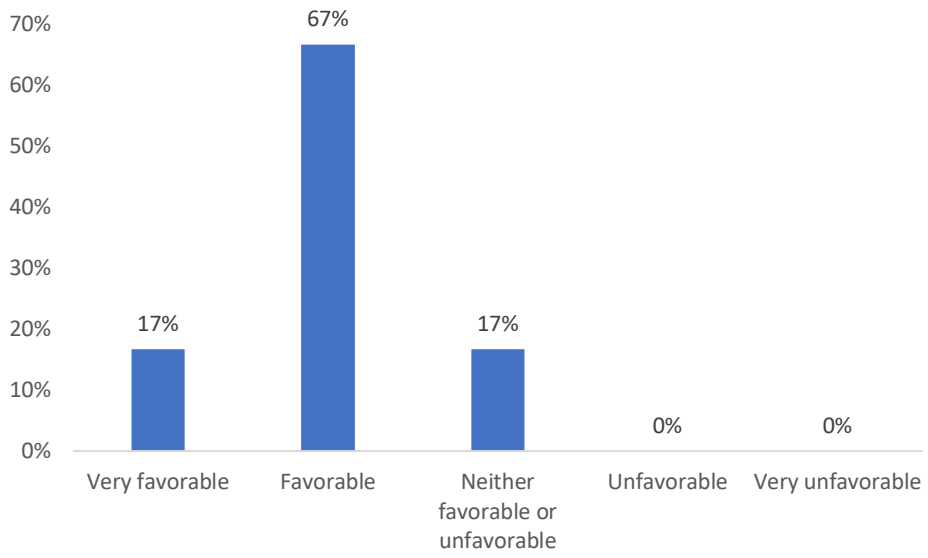
Survey respondents were relatively evenly split in serving the metro (44%), northern regions (44%), and the southern regions (39% — respondents could indicate they served more than one region). Most contractors we spoke with worked in small companies with 1–5 employees (78%); no one indicated they worked for a company with more than 20 employees. Participants also had mixed experience levels with heat pumps where 41% indicated they install ASHPs regularly, and 24% said they had not installed them; the remainder had installed a few, but not regularly.

Findings

ASHP perceptions

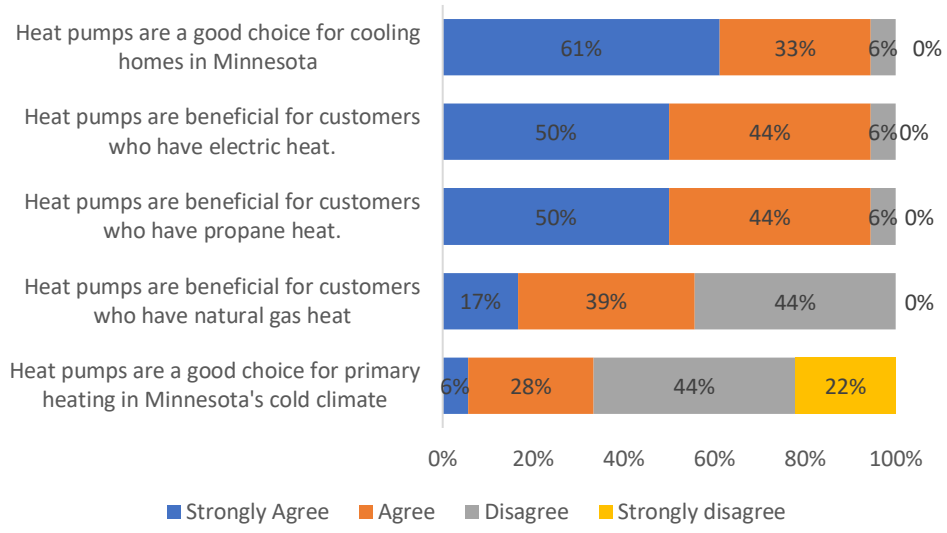
The vast majority of contractors indicated they had a favorable opinion of heat pump technology (83%; Figure 12). When asked why they held that opinion, three or more indicated ASHPs were higher efficiency, had decreased fossil fuel use, had advanced technologically, and were good for warmer areas or times of the year. Two people also mentioned that it can save money, provides both heating and cooling, pairs with multiple applications or heat source, and that the industry is moving that direction. However, five people also mentioned that ASHPs have poor performance in the cold weather, and three mentioned cost as an issue.

Figure 12. General opinion of heat pumps (N=17)



Despite the favorable general opinion, most felt that heat pumps were not a good choice for primary heating in Minnesota's cold climate (Figure 13). However, the vast majority felt that they were a good choice for cooling homes and beneficial for customers with propane and electrically heated homes. Responses were more mixed about customers with natural gas heated homes.

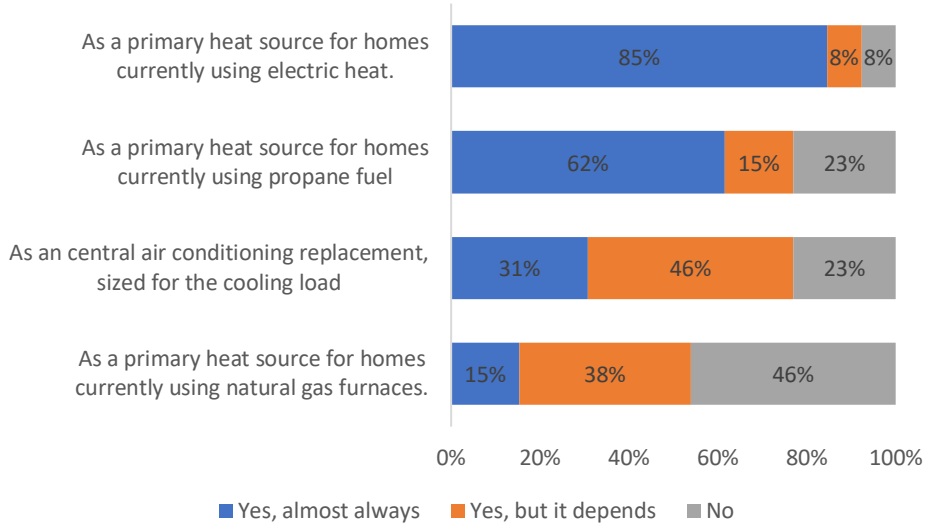
Figure 13. Agreement with specific applications for ASHPs (N=18)



Similarly, we asked those who had experience installing at least a few ASHPs to weigh in on when they would recommend ASHPS. The vast majority (85%) said they would almost always recommend them as a primary heat source for people currently using electric heat (Figure 14). The majority (62%) would also almost always recommend them for homes using propane. As a CAC replacement, responses were more mixed with nearly half (46%) saying yes, but it depends.

Nearly half (46%) said they would not recommend them as a primary heat source for homes using natural gas furnaces.

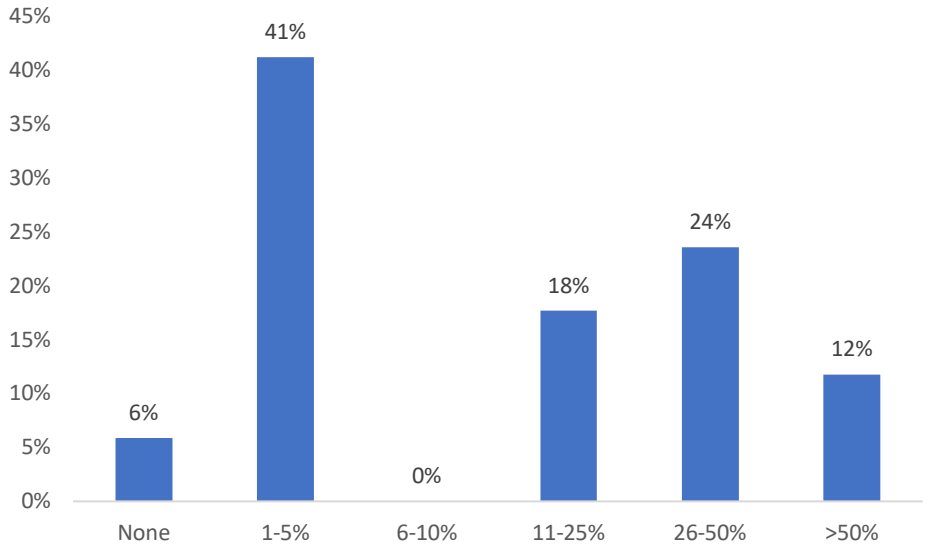
Figure 14. Would you recommend ASHPS for the following circumstances? (N=13)



ASHP sales

Heat pump sales represented a wide range of respondent's business, with 41% indicating that heat pump sales make up between 1–5% of current sales and 41% indicating they make up greater than 25% of sales (Figure 15).

Figure 15. What percentage of your current sales are from heat pumps? (N=17)



Within that, respondents were similarly split on how much of those sales were ducted models, with 29% indicating it was between 1–25% of their sales, and 29% indicating it was greater than

75% of their sales. The vast majority said their heat pump sales have increased over the past few years, or they expect it to increase.

When asked about the future, the majority of respondents indicated that heat pump sales overall will increase over the next five years (83%), and most felt it would increase a lot (61%). No one felt sales would decrease. When asked to describe why they felt that way, nearly half (8) mentioned incentives or policy, including tax credits, utility rebates, and political motivation, as a driver for heat pump sales. At least three people also mentioned the following drivers: technology is continuing to advance, especially for cold climate options; increasing gas costs could make heat pumps more appealing; increasing awareness among various actors; and climate or environmental motivations.

Respondents were also asked how the sales trajectory differed for ducted versus ductless heat pumps, and their responses were mixed. Seven noted that ductless sales specifically would rise describing that they are a good option for installing cooling, have a lower price point, and are versatile for particular applications, especially homes without ductwork. Four mentioned that sales in ducted applications would increase, noting that they can be a good replacement for central air and homes that already have ducted systems. Five mentioned that they felt both markets would increase together.

To get a better sense of how heat pumps fit into their current offerings, we asked if they include heat pumps in their standard bidding processes alongside air conditioners for cooling needs, such as in a good, better, best lineup. Responses were mixed and roughly half said they did offer heat pumps in their bidding processes, though for some this was infrequent and not always in a good, better, best lineup.

Customer education and processes

When asked if they currently advertised or provided education to consumers about heat pumps to consumers, 56% said they did. Of those, at least three respondents mentioned putting materials on their websites and sharing information directly with the customer. When asked to describe the kinds of information they share, at least two people mentioned discussing rebates or incentives, how it works or what it is, efficiency or effectiveness, considerations for the home (such as noise, footprint, how it works with their home), and their personal experience. One person noted that their own experience has been the strongest argument to promote heat pumps.

We also asked respondents to describe the process if a customer asks for a heat pump. Most started by saying they would give people information. This included information about how ASHPs work and differences between ASHP and ACs, efficiency, options, or differences in equipment, rebates/incentives, savings, and other benefits (each mentioned by at least two people). Three people noted that they start with going to the home or seeing what the customer currently has onsite and decide appropriate options from there. Three people also mentioned getting pricing from the supplier or sending an estimate as a part of the process, though this is likely part of the process for most contractors if a customer is considering moving forward with an option. The process also likely depends on the customer, and three people mentioned this or

discussed what people want or need. One person said that people don't ask for them, and another said they discourage people from ASHP.

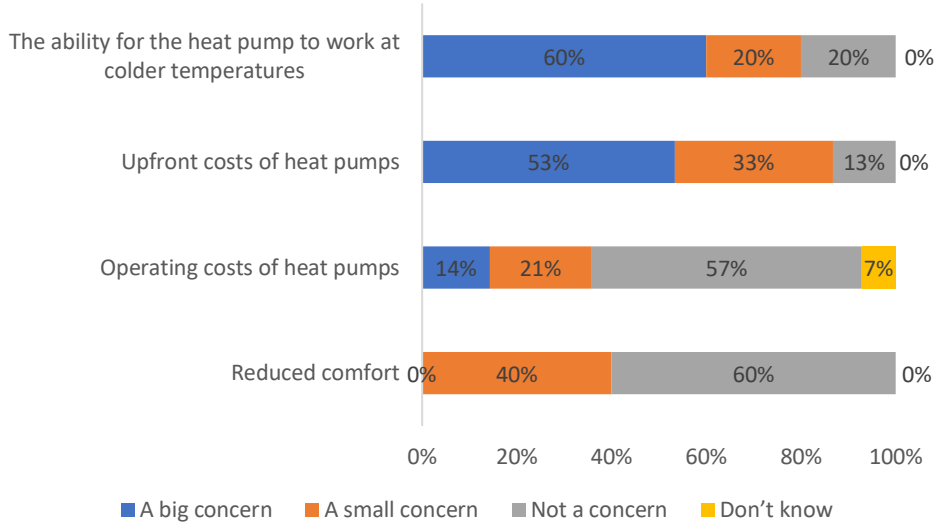
Benefits

To assess awareness of and saliency of benefits, we asked contractors to describe the top two to three potential benefits for customers. Respondents were not given response options, so they could freely list what they were thinking. Half of all respondents said saving money is a key benefit, and nearly half mentioned similar themes of efficiency or energy savings and incentives like rebates and tax credits. This indicates that contractors feel the financial component of the value proposition is the biggest factor for customers. A quarter of respondents also mentioned the ability to both heat and cool a space, carbon reduction or environmental sustainability, and the benefit of having multiple fuel types, especially to insulate against gas cost spikes. At least two people also discussed zonal control and comfort as top benefits. In general, participants also mentioned these perceived benefits are similar to the selling points they use.

Challenges

While we asked about benefits in an open-ended manner, we asked specifically how much of a concern contractors felt certain items were to customers to gauge the perceived magnitude of a barrier. Most respondents say that upfront costs and the ability for the heat pump to work at colder temperatures were big concerns (Figure 16). When asked to describe any additional key concerns, multiple contractors noted snow conditions, cleaning and maintenance, unfamiliarity with the technology, installation process and potential upgrade needs, and life expectancy of the equipment.

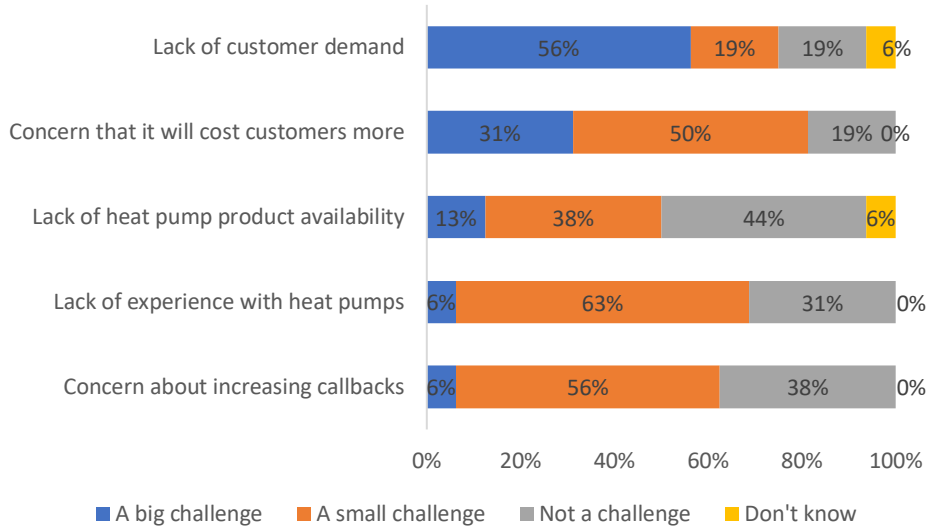
Figure 16. How big of a concern do you think each of the following are for customers? (N=14-15)



As contractors are a trusted source of information and product, we also wanted to know what challenges contractors themselves had with incorporating more heat pumps into their business.

More than half said that a lack of customer demand was a big challenge, and three-quarters said it was at least a small challenge. Relatedly, concern that it will cost customers more was at least a small challenge for more than 80%. The vast majority indicated other issues were smaller challenges or not a challenge (Figure 17).

Figure 17. How big of a challenge are the following for incorporating more heat pumps into your business? (N=16)

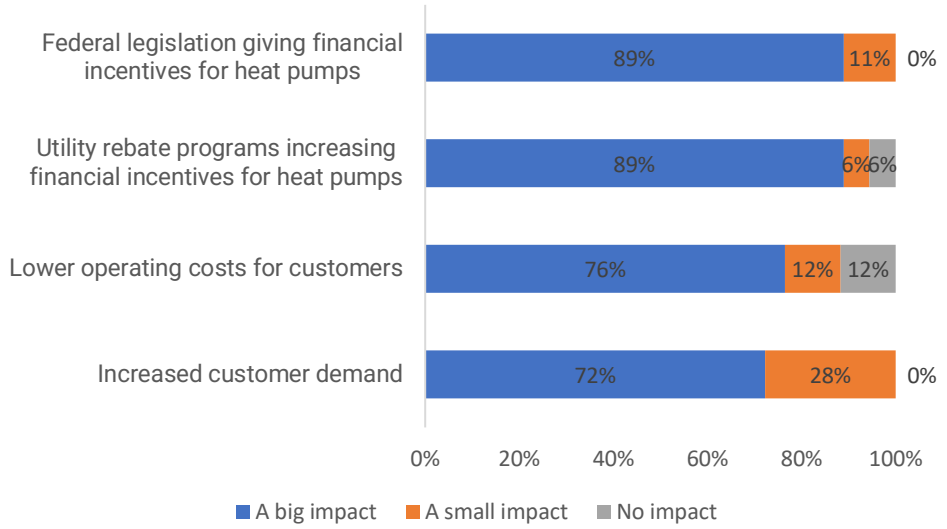


ASHP catalysts

When asked what would make them more likely to install more ASHPs, nearly half of contractors who responded mentioned rebates and incentives. This is a key driver. Relatedly, a couple respondents each mentioned lower costs and natural gas price changes to make the economics more feasible. The other key theme was around more information for both contractors and consumer. This included training for contractors and more marketing and materials for the public.

When asked specifically about key potential catalysts, nearly 90% said that federal legislation giving financial incentives for heat pumps and utility rebate programs increasing financial incentives for heat pumps would have a big impact (Figure 18). Around 75% also said increased customer demand and lower operating costs would have a big impact.

Figure 18. How much of an impact do you think the following will or would have on incorporating more heat pumps into your business? (N=17-18)



Resources

When asked what resources might be helpful, half of those who responded said consumer-facing materials or marketing would be helpful. Four mentioned contractor training would be helpful, and at least two mentioned more product information and specific savings data would be helpful. Respondents noted that this information could come from manufacturers, utilities, online resources, and CEE's ASHP Collaborative. When asked explicitly where they go to get information about heat pumps, 7 of 15 mentioned distributors, 6 mentioned manufacturers, and three each mentioned utilities and the internet, and one mentioned CEE, so these findings were corroborated across questions.

Conclusions

Overall, several themes from the research emerged and they provide opportunities for ETA to plug in and support change. In general, contractors hold a favorable opinion of ASHPs, though skepticism remains, and they are expecting ASHPs to grow and gain momentum. They also indicate that there are opportunities to provide education to both consumers and to contractors, and that the financial components of the value proposition will be critical to driving adoption. These themes are discussed below.

Favorable opinion of ASHPs overall, though skepticism remains

Most contractors had a favorable opinion of heat pumps, and they would generally recommend them for propane and electric fuel applications. However, they still don't feel that they are the right choice for primary heating in Minnesota's cold climate and for those with natural gas. Contractors held mixed opinions on cooling applications — while most strongly agreed ASHPs

were a good choice for cooling homes in Minnesota, they were more hesitant to recommend them as a CAC replacement, with nearly half saying that they would consider recommending them, but it depended on the circumstances. More work will need to be done to demonstrate the efficacy of heat pumps in Minnesota's climate and with CAC replacement, as well as improve the value proposition for natural gas applications.

Growth and momentum

Currently, only a couple contractors mentioned ASHPs comprise more than half of their total sales, and highest proportion of contractors said ASHPs only make up 1–5% of their total sales. This suggests large room for market growth. Contractors expected ASHP sales to grow, most of them suggesting it would grow substantially over the next 5 years, with incentives and policy, among other factors, driving sales. The market is therefore likely preparing for an increase and external momentum can be leveraged.

Opportunities to increase awareness

About half of respondents indicated they provided education to consumers on ASHPs — half also said that consumer facing materials or marketing would be helpful to them, and some indicated that additional information would help them install more ASHPs. A lack of customer demand was also the biggest challenge noted by contractors. Thus, ETA could consider providing support and materials to contractors for increasing consumer education and demand. While about half of contractors indicated they offered ASHPs in their bidding processes, it was not consistent. Bidding processes could also be a place to help increase exposure and customer offerings.

Contractors also mentioned that training would be helpful, and most contractors felt that lack of experience was at least as small challenge to incorporating more heat pumps into their business. Providing or supporting contractor training could be another opportunity for ETA.

Financial component is key

Contractors felt that the financial component of the value proposition is a key driver for customers (saving money, energy savings, incentives, etc.), and that upfront costs were a big concern for customers. They also noted that rebates and incentives would make them more likely to install more ASHPs, and that federal legislation and utility programs increasing financial incentives would make a big impact for incorporating more ASHPs in their business. Making the finances of ASHPs attractive to consumers and ensuring they can take advantage of incentives will be critical for increasing adoption. Additional benefits like ability to heat and cool, carbon reduction, and multiple fuel types were also salient. These could also be leveraged in consumer messaging.

Phone interview results data tables

A1. What region or regions of the state do you serve?

Region (N=18)	n	%
South	**7**	**39%**
Southeast	3	
Southwest	2	
West Central	2	
North*	**8**	**44%**
Northeast	2	
Northwest	1	
Central	4	
Metro	**8**	**44%**

*One respondent noted they worked in the East Central region, which could encompass the Northeast, Central, or northern portion of the Metro. We have included them in the North region but they are not represented in the subdivision below.
Note: Respondents could describe more than one region, so percentages do not sum to 100%.

A2. About how many employees does your company have?

Employees (N=18)	n	%
1-5	14	78%
6-20	4	22%
>20	0	0%

A3. How much experience do you have with heat pumps?

Experience (N=17)	n	%
A lot – you install heat pumps regularly	7	41%
Somewhat – you have installed a few, but do not install them regularly	6	35%
Not much – you have looked into them, but have not installed any	4	24%

Not at all – you have not looked into them nor installed any	0	0%

A4. In general, what is your opinion of heat pump technology?

Opinion (N=18)	n	%
Very favorable	3	17%
Favorable	12	67%
Neither favorable or unfavorable	3	17%
Unfavorable	0	0%
Very unfavorable	0	0%

A5. Level of agreement around heat pump applications

	Strongly Agree		Agree		Disagree		Strongly disagree	
(N=18)	n	%	n	%	n	%	n	%
Heat pumps are a good choice for primary heating in Minnesota's cold climate	1	6%	5	28%	8	44%	4	22%
Heat pumps are a good choice for cooling homes in Minnesota	11	61%	6	33%	1	6%	0	0%
Heat pumps are beneficial for customers who have electric heat.	9	50%	8	44%	1	6%	0	0%
Heat pumps are beneficial for customers who have propane heat.	9	50%	8	44%	1	6%	0	0%
Heat pumps are beneficial for customers who have natural gas heat	3	17%	7	39%	8	44%	0	0%

A6. Would you recommend heat pumps for the following circumstances?

(N=13)	Yes, almost always		Yes, but it depends		No	
	n	%	n	%	n	%

As a central air conditioning replacement, sized for the cooling load	4	31%	6	46%	3	23%
As a primary heat source for homes currently using propane fuel	8	62%	2	15%	3	23%
As a primary heat source for homes currently using electric heat.	11	85%	1	8%	1	8%
As a primary heat source for homes currently using natural gas furnaces.	2	15%	5	38%	3	46%

Note: this question was only asked of those who said they installed heat pumps a lot or somewhat.

A7. About what percentage of your current sales are from heat pumps?

Sales (N=17)	n	%
None	1	6%
1-5%	7	41%
6-10%	0	0%
11-25%	3	18%
26-50%	4	24%
>50%	2	12%

A8. What proportion is ducted?

Ducted proportion (N=17)	n	%
None	1	7%
<25%	4	29%
25-49%	2	14%
50-74%	3	21%
75+%	4	29%

A9. How do you expect heat pump sales to change over the next 5 years?

Sales trajectory (N=18)	n	%

Increase a lot	11	61%
Increase a little	4	22%
Stay the same	3	17%
Decrease a little	0	0%
Decrease a lot	0	0%

A10. Do you currently advertise or provide education to consumers about heat pumps?

(N=16)	n	%
Yes	9	56%
No	7	44%

A11. Do you include heat pumps into your standard bidding processes alongside air conditioners for cooling needs, for example in a good, better, best lineup?

(N=14)	n	%
Yes	7	56%
No	7	44%

A12. How big of a concern do you think each of the following are for customers?

	A big concern		A small concern		Not a concern		Don't know	
(N=14-15)	n	%	n	%	n	%	n	%
Upfront costs of heat pumps	8	53%	5	33%	2	13%	0	0%
Operating costs of heat pumps	2	14%	3	21%	8	57%	1	7%
The ability for the heat pump to work at colder temperatures	9	60%	3	20%	3	20%	0	0%
Reduced comfort	0	0%	6	40%	9	60%	0	0%

A13. Please tell us how big of a challenge the following are for incorporating more heat pumps into your business.

	A big challenge	A small challenge	Not a challenge	Don't know

(N=16)	n	%	n	%	n	%	n	%
Lack of experience with heat pumps	1	6%	10	63%	5	31%	0	0%
Lack of customer demand	9	56%	3	19%	3	19%	1	6%
Lack of heat pump product availability	2	13%	6	38%	7	44%	1	6%
Concern that it will cost customers more	5	31%	8	50%	3	19%	0	0%
Concern about increasing callbacks	1	6%	9	56%	6	38%	0	0%

A14. How much of an impact do you think the following will or would have on incorporating more heat pumps into your business?

	A big impact		A small impact		No impact	
(N=17-18)	n	%	n	%	n	%
Federal legislation giving financial incentives for heat pumps	16	89%	2	11%	0	0%
Utility rebate programs increasing financial incentives for heat pumps	16	89%	1	6%	1	6%
Increased customer demand	13	72%	5	28%	0	0%
Lower operating costs for customers	13	76%	2	12%	2	12%

APPENDIX B. COMPETING TECHNOLOGIES

Competing options

Baseline heating and cooling technologies

Minnesotans have multiple technology options for heating and cooling their homes. Many competing technologies have been around for decades and are now experiencing mature market forces and slowed rates of technological advancement. Comparatively mature, non-electric heating technologies include furnaces, stoves, and boilers. Natural gas, propane, biomass, and oil burning versions of each of these systems are available, with natural gas and propane systems being by far the most common in the state. Local fuel availability and price usually determine which fuel type will be selected since equipment costs for a given technology do not vary significantly based on this factor. Typical energy efficiencies do not vary significantly either and are always below 100%. Efficiencies are limited because the provided fuel in these systems is directly converted into heat through combustion. In practice, even the most efficient models of these systems will see losses of at least 5% from the ideal efficiency. Lower efficiency models can lose 25% or more. Equipment costs for these technologies are comparable or significantly less expensive than ASHPs. These mature technologies also offer a wider range of heat output capacities for residential units. Systems are available which can output as much as about twice as much heat per hour than that of the largest residential ASHPs currently available.

The main difference between furnaces, stoves, and boilers are in their distribution methods. Furnaces employ ductwork and a central air handler to distribute their heat output by forced air. Thus, they can be combined with central air conditioners (CACs) or ASHPs to provide cooling and dehumidification. In contrast, boilers use hydronic distribution systems. A wide array of hydronic emitters is available. Older homes with boilers in Minnesota commonly use cast iron radiators or hydronic fin-and-tube baseboards while newer homes are more likely to have in-floor radiant hydronic heat. New builds may use these same emitter types or include more advanced emitters, such as fan coils. Fan coils can also be used for cooling, unlike the previously mentioned emitter types, which can develop problematic condensation when chilled. Fuel-burning boilers do not commonly interface with a CAC unit like furnaces do, however, and fan coils remain uncommon in Minnesota's housing stock. Lastly, stoves use neither forced air nor water to distribute heat throughout an entire home. Instead, they deliver heat primarily through radiation and natural convection alone. Their limited ability to distribute heat evenly throughout a home make them an uncommon choice for a primary heat source. Instead, they are more likely installed as back-up or localized supplementary heaters due to their low cost and ability to operate without electricity.

The most mature all-electric heating alternative to ASHPs are electric resistance (ER) systems. These systems come in every shape and form imaginable including furnaces, boilers, portable space heaters, in-floor radiant heat, baseboard, and wall heater units. Like fuel-burning heaters, ER heaters are also limited in their efficiency. Maximum site efficiencies nearly approach, but

never exceed, 100%. The overall source efficiency will vary depending on the local electrical grid mix. Compared to fuel-burning heat, ER heat often has higher operational costs but lower upfront equipment costs. Compared to ASHPs, ER systems are also cheaper to install but more expensive to operate given their lower efficiencies. In addition, electric thermal storage units have a presence in the Minnesota market. These units produce electric heat and can store heat and integrate with utility demand response programs. This allows the heating systems to leverage off-peak electricity to heat homes more cost-effectively.

Baseline cooling systems are either one-way, centrally ducted air conditioning units that can integrate with the heating systems described above, window air conditioning units or no cooling in homes without ductwork. These cooling systems come in a range of efficiency ratings. Cooling system replacement or the addition of cooling is often an opportunity for an ASHP installation.

Competing emerging technologies

Mature and efficiency-limited HVAC technologies are not the only alternatives to ASHPs. Several distinct varieties of heat pumps are also available or are emerging rapidly for home heating applications. Heat pump technologies are generally categorized based on three distinguishing factors. These include:

1. The “source” reservoir type from which heat is drawn or to which it is dumped external to the building
2. The distribution method used to deliver heat throughout the building
3. The primary energy input method used to drive heat in or out of the building

The ideal source reservoir is one with lots of heat to give when the home must be warmed, and plenty of capacity to receive heat when the home must be cooled. This is a clear challenge for heat pumps using the outdoor air as a source reservoir, but alternative approaches have been developed to capitalize on sources with more opportune temperatures. A description of the heat pump varieties in each category follows.

ASHPs use outdoor air as their source reservoir. Thermal energy is extracted from the air to heat the home and deposited to the air to cool the home. Air temperatures in Minnesota typically vary by more than 110°F over the course of a year, making outdoor air an imperfect thermal reservoir. A few feet below the frost line, however, temperatures remain relatively constant underground. Ground source heat pumps (GSHPs) exchange heat between a building and the ground, taking advantage of ground temperatures that are warmer than the outdoor air in winter and cooler than the air in summer. To exchange heat with the ground, GSHPs circulate a liquid solution through an array of buried pipes. GSHPs can be further categorized based on the orientation, shape, or size of this ground loop. A variation on the GSHP is a water source heat pump, wherein the reservoir loop is installed in a deep body of water instead of the ground.

GSHPs are also called geothermal, earth-coupled, or GeoExchange heat pumps and have been available since the late 1940s.[25]

GSHPs typically perform better than ASHPs, except in terms of installation cost and ease. The ground loop installation cost varies based on local climate, soil conditions, and available land. Depending on the site details, the loop installation alone can be several times the cost of an ASHP. However, if the space is available and ground favorable, the improved energy savings from a GSHP can yield payback periods around 5 to 10 years. The long-term cost efficacy of GSHPs in ideal situations can match or significantly improve upon that of an ASHP while in other cases may be practically impossible to implement. Water source heat pump performance lies in between that of an ASHP and a GSHP, assuming a suitable body of water is available. Unlike ASHPs, GSHPs and water source heat pumps often use hydronic distribution systems and can be designed to cover domestic hot water heating loads in addition to the home heating and cooling loads.

Integration of hot water and home heat loads combined with an opportunity for improved distribution efficiency makes hydronic distribution systems appealing. Air-to-water heat pumps (AWHPs) are a type of heat pump that enable hydronic distribution without requiring a GSHP or water source system. While not strictly specified in the name, ASHPs usually refer to air-to-air heat pumps. That is, the ASHP delivers heat to the building directly through forced air distribution. An AWHP is like an ASHP that includes a heat exchanger to heat a hydronic loop first. The hydronic loop can then use various hydronic emitters to deliver the heat to the home through radiation, natural convection, or even forced air across a hydronic coil. Low temperature emitters are required, however, as AWHPs do not deliver water temperatures as high as fuel-burning boilers. This requirement is a significant barrier for retrofitting Minnesotan homes with AWHPs currently on the market. Though they are well established in Europe, AWHPs are only very recently available in Minnesota and are just now being evaluated for their performance in the state. Cold-climate AWHP systems available now cost around 1.5 to 5 times that of an air-to-air ASHP with similar levels of performance expected. However, as AWHP technologies mature, their potential benefits for load integration, thermal energy storage, and use of advanced refrigerants may close the cost efficacy gap between these types of heat pumps.

The last alternative heat pump type that is under development are absorption heat pumps. Unlike all the previously described heat pumps, absorption heat pumps are primarily driven by a combustion heat source instead of electricity. The heat source may be natural gas, propane, solar-heated water, etc., but natural gas is the most common driver for absorption heat pumps. As a result, they are often called gas-fired heat pumps. The absorption cycle they use is like the refrigeration cycle used by other heat pumps. When the working fluid is condensed, it heats and when it evaporates, it cools. However, residential absorption heat pumps use an ammonia-water absorption cycle wherein ammonia is absorbed into water after the evaporation phase, allowing a low-power pump (instead of a compressor) to increase its pressure during the

[25] Energy.gov, "Geothermal Heat Pumps." Available here.

condenser phase. In turn, the heat source (usually gas) is used to boil the ammonia back out of the water prior to the evaporation phase, restarting the cycle over again. Heat from the air (indoor or outdoor, depending on cooling or heating mode) is also absorbed by the ammonia during the evaporation phase. This increases the efficiency above 100%. Absorption heat pumps have mainly been used in industrial or commercial settings so far, but units sized for very large homes are becoming available and may find various different distribution methods and applications in Minnesota soon.