EFFICIENT TECHNOLOGY ACCELERATOR

Air Source Heat Pump Market Transformation Plan

Center for Energy and Environment

Fall 2023

V.20230912

Contents

INTRODUCTION

Minnesota Efficient Technology Accelerator

The Minnesota Efficient Technology Accelerator (ETA) is a statewide market transformation program that accelerates deployment and reduces the cost of emerging and innovative efficient technologies, bringing lower energy bills and environmental benefits to Minnesotans. The ETA is a partnership funded by the state's investor-owned utilities (IOUs), administered by the Minnesota Department of Commerce, Division of Energy Resources (DER), and implemented by Center for Energy and Environment (CEE).[1]

The ETA program has set four overarching goals:

- Create a strategic process to accelerate market deployment of key technologies.
- Employ effective strategies to leverage market forces.
- Become a hub for collaboration among stakeholders.
- Achieve cost-effective energy savings and other benefits for utilities and Minnesotans.

The ETA program develops individual market transformation initiatives for a handful of targeted technologies and approaches, often starting at an early stage of development. The ETA approach involves working closely with market partners and other key stakeholders. Initiatives move through four stages of a life cycle that includes: 1) concept development; 2) program development; 3) market development; and 4) long-term monitoring and tracking. The majority of effort and resources are spent during the market development stage, which is the "implementation" stage that involves intensive market engagement. Before moving from one stage to the next, an initiative must be vetted and approved by a coordinating committee consisting of the DER and the utilities funding the ETA.

Purpose of this plan

The Market Transformation Plan is the culmination of the program development stage, where extensive research and planning is done to prepare the initiative for market launch. The purpose of this plan is to summarize key contextual information, lay out the basic program logic and desired end state that informs our market strategy, and the present the fundamental market support activities necessary for success. This plan will then be the guide in developing specific activities each year during the market development phase. By being transparent in our objectives and strategies as much as possible, we hope to better facilitate stakeholder engagement, and alignment on strategy with key stakeholders, so we can together be coordinated and successful in achieving common goals. Supporting and informing this plan are

[1] Minnesota Statutes § 216B.241 subd. 14 created the framework for the ETA program, which is funded by Xcel Energy, CenterPoint Energy, Minnesota Energy Resources, Minnesota Power, and Otter Tail Power.

the Market Characterization Report and the Energy Savings and Evaluation Plan (Appendices A and B).

Summary of our approach

This section contains a brief summary of our approach, including our theory of how we expect to transform the market for air source heat pumps (ASHPs).

Space heating consumes the most energy in residential homes in Minnesota, with a high potential for energy and greenhouse gas emissions savings.[2] ASHPs offer a more efficient and climate-friendly alternative to homes heated by electric resistance, propane, and traditional gas-fired furnaces paired with an air conditioner (AC) for residential space heating and cooling.[3] By moving heat instead of creating it, ASHPs that heat homes are between 150% and 400% efficient and contribute to reducing emissions in line with the transition to a carbon-free grid by 2040 in Minnesota.

Currently, an estimated two thirds of single-family Minnesotan households heat their homes with gas furnaces and cool with AC and could instead meet a portion of their home heating needs and continue to cool by replacing their AC with an ASHP. This initiative has the potential to reduce Minnesota's residential heating and cooling energy usage by roughly 35%.[4]

There are an array of market barriers and opportunities that could greatly impact the trajectory of ASHPs. First, upfront cost is a major barrier, as the equipment is much more expensive than standard AC equipment. However, this landscape is rapidly changing with new utility, state, and federal rebates on the way.[5] Incentive levels, specification requirements, and ultimately more competitive bids will be necessary to fully address this market barrier.

Secondly, ASHPs can be more expensive to operate than heating with natural gas, especially below moderate outdoor air temperatures (e.g., 20–30°F), or they may only result in modest savings or neutral costs. Dual fuel or electric space heating rates could provide customers with lower rates that properly value the grid benefits that dual fuel ASHPs offer, reducing the operational costs significantly. However, these rates are available to few customers in Minnesota or come with expensive requirements like the need for a second utility meter.

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[2] EIA Residential Consumption Data, 2020, available here.

[3] For more info, see CEE's website on ASHPs, here.

[4] 2020 Residential Energy Consumption Survey microdata estimates a total of 90,000,000 MMBtu was used for heating and cooling energy for in-scope homes in 2020 (including electricity used for space cooling and gas or propane used for main and secondary space heating). The methodology for calculating technical potential is discussed in more detail in the energy savings and evaluation plan for this initiative.

[5] 2024–2026 utility triennial plans contain higher rebates than historical levels for ASHPs. In addition, the 2022 Inflation Reduction Act (IRA) opens the door for additional incentives through financing opportunities, tax credits, and rebates. Lastly, in 2023, Minnesota passed legislation enabling additional rebate dollars for ASHPs.

Third, many contractors hesitate to recommend and install ASHPs, especially in Minnesota’s heating-dominated climate. Contractors’ acceptance has increased over the last three years but there is still hesitancy to install heat pumps as a primary heat source. There are opportunities to work with manufacturers, distributors, and utilities to support contractors’ acceptance and promotion of the technology and cultivate a network of heat pump champions to promote the technology to customers.

We will overcome these barriers and leverage the opportunities through market support strategies. These strategies will require deep engagement with various market actors including manufacturers, distributors, and contractors. Key strategies include creating powerful tools, messaging, and resources that cities, the state, utilities, and others can use to drive customer awareness; working closely with the supply chain to help cultivate heat pump champions through training and support; and working with utilities and the state to align rebate offerings and improve electric rates to make heat pumps more affordable and accessible to customers.

As public interest and policies continue to shift towards a low-carbon future and the engagement efforts within this initiative are implemented, demand for ASHPs will increase. As ASHP performance improves and contractors become more trained and familiar with the technology, they will become champions for ASHPs, driving customer adoption and creating a competitive marketplace for ASHP equipment and installation. As the market continues to develop and mature, the overarching aim for this initiative is by 2035 to have a code or standard in place to make ASHPs instead of ACs the standard choice for home heating and cooling.

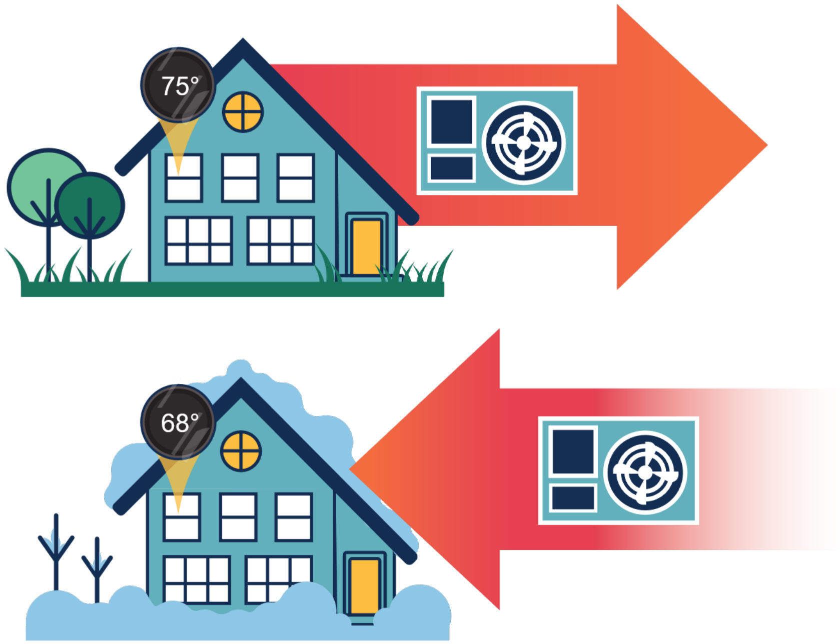
Additional documentation about the market transformation theory logic and evaluation is in Appendix B.

PRODUCT INFORMATION

Product description

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 the inside the home. Unlike ACs, heat pumps can reverse the direction of the refrigerant flow to provide both heating and cooling. As mentioned, a heat pump moves heat instead of creating it. For this reason, this technology can be between 150% and 400% efficient because the energy required to move the heat can be less than the amount of heat that the refrigerant cycle can move.

Figure 1. Diagram of an ASHP bidirectionally moving heat in summer and winter.



ASHPs have been used for many decades in North America. Legacy equipment typically had one or two stages of heating and cooling capacity output and have been widely used in southern states with warmer climates or with an auxiliary heating source in colder climates to ensure heating load is met. During the last decade, a new wave of this technology entered the market and is widely known as variable speed, variable capacity, or inverter-driven equipment. These terms are synonymous. This new technology provides higher levels of efficiency and higher capacity at colder outdoor air temperatures.

Application types and focus

Application types

Residential ASHPs have many applications. They can be appropriate for homes with centrally ducted systems, homes without ductwork (i.e., ductless), multifamily buildings, and light commercial. They can displace or fully replace a variety of fuel types including electricity, propane, natural gas, biofuel, and fuel oil. The first three are the primary fuel types in Minnesota.

Focus

For this initiative, the focus is for ASHPs to replace ACs and pair with a natural gas or propane furnace in a hybrid or dual fuel manner in homes with central ductwork. This market segment represents the largest share of Minnesota households (53%).[6] Other areas of the market have accelerated more quickly. For example, according to HVAC distributor and MN electric utility rebate data, ductless heat pump sales grew faster than centrally ducted ASHP sales. Therefore, we chose not to focus this initiative on the ductless application type. Despite this initiative's focus on centrally ducted ASHPs, we recognize there may be spillover effects into other areas of the broader ASHP market. The initial target is centrally ducted AC (CAC) replacement with an ASHP to provide heating benefits alongside a furnace, with increasing heating benefits through multiple tiers described in the following.

When looking exclusively at this application focus, 1.17 million homes in the state have centrally ducted furnaces paired with CACs with low to moderate SEER ratings.[7] By replacing the CAC with ASHPs, homeowners can receive more efficient cooling and cost-effective, low-carbon heat in the shoulder seasons, as well as increased price resiliency by having multiple systems and fuel types to provide home heating.[8]

The CAC replacement technology under this initiative may or may not be variable speed. Current research underway will help refine the ideal product specifications for energy savings, carbon reduction, operational cost benefits, first cost, and non-energy benefits. The technology can be single-stage, two-stage, or variable speed. Typically, single-stage units have a relatively lower cost and variable speed systems cost more. There are many systems available depending on the homeowner's desire to replace both the furnace and AC or just the AC. For proper functionality and optimal performance, most variable speed systems are installed in combination with a furnace. However, the most recent advances are variable speed system types that can be integrated with any existing furnace and thermostat. This allows for maximum flexibility and lower initial costs to install.

Product specification

This initiative defines two tiers for centrally ducted ASHPs. Tiers 1 and 2 are common in the market but require specification to identify what meets these tiers. Entry level ASHPs are widely available, have a low incremental cost, and can offset some natural gas or propane heat. This tier is meant to be widely accessible and can target the AC replacement market where cost and time constraints are more pronounced. The overall purpose of this product tier is to encourage the installation of an ASHP over a CAC in all cases with speed to scale and assume a large

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[6] EIA, "2020 Residential Energy Consumption Survey Microdata" (2020). Available here. This percentage represents the total number of in-scope households (attached/detached single family and 2-4 unit multifamily) with this HVAC application type (centrally ducted with natural gas or propane furnace and AC) compared to the total number of households in Minnesota. Roughly two thirds of the in-scope building stock are encompassed by this HVAC application type.

[7] U.S. Federal Register, "Energy Conservation Program: Energy Conservation Standards for Residential Central Air Conditioners and Heat Pumps" (2017). Available here. Low seasonal energy efficiency ratio (SEER) ratings are evident from MN distributor sales data and at the cited link.

[8] For further detail on savings, see the savings potential section below.

portion of the market in a short amount of time. The Tier 2 product type applies to homeowners who have existing propane heat and thus a compelling payback incentive to offset a much larger fraction of the heating load. This tier is also helpful for a customer who might be highly motivated to more fully electrify and may not be as conscious of or sensitive to operating costs or payback.

- **Tier 1 is composed of any ASHP chosen instead of an AC that will displace some furnace operation.** This product will at least meet the federal minimum standard typically sized for the cooling load (and by result not sized to satisfy the entire heating load). This tier reflects an entry level product with low cost. This lower-tier product may have less heating capacity at lower ambient temperatures (due to equipment sizing and the product class's performance at lower temperatures), and so will require a switchover temperature[9] at a higher relative temperature compared to the capability of a Tier 2 product (e.g., 30–35°F switchover to a secondary heat source).
- **Tier 2 is composed of a variable speed ASHP sized to cover most of the heating load and will have suitable efficiency and capacity that can be maintained well at cold temperatures typical in Minnesota's climate.** Switchover temperatures can be adjusted according to fuel type and fuel costs to find an appropriate balance between costs and electrification for the occupant(s). In this tier, switchover temperature can be set to maximize cost savings or energy savings. For example, since natural gas is typically a lower cost fuel to use for heating, this may not warrant a lower switchover temperature. On the other hand, this product tier is appropriate and capable to displace or fully replace a larger portion of more expensive fuels such as propane.

State of the product

ASHPs exist generally in the residential HVAC market, but are less widespread compared to competitive products, mainly furnaces and ACs. Standard, low-efficiency ASHP technology has been in the market for decades. These are more prevalent in areas of Minnesota served by delivered fuels such as propane because they have competitive operational costs, can be used in a dual fuel or hybrid manner, and are widely supported by utility programs with off peak or dual fuel electric rates and equipment rebates. More recently, product advancements in the variable speed product category allow ASHPs to work more efficiently and have better heating capacity in colder climates.

Ducted vs. Ductless

Ductless ASHPs. These systems are typically installed in homes heated with electric resistance baseboards or boilers, trouble spots like attics, homes that may be too hot or cold, or in retrofit applications. This is a common product in Asia, Europe, and other parts of the world. This

[9] A switchover temperature in this case refers to the outdoor air temperature at which the heating system changes from the ASHP to the furnace.

equipment category is seeing high growth in MN, especially relative to ducted systems, due to their high efficiency, comparative ease of installation, and the ability to add cooling to homes without ductwork (e.g., homes with boilers) that may have been without cooling or were cooled with window AC units. These units are typically variable speed and usually require operation in conjunction with the previously installed primary heating system to properly meet the heating load.

Figure 2. Example of a ductless ASHP

Ducted ASHPs. These systems are typically centrally ducted and paired with a propane or natural gas furnace, electric furnace, or air handler combined with an electric resistance plenum heater.

Figure 3. Example of a ducted ASHP

Outdoor unit types

Side discharge fan ASHPs. These units have a fan oriented horizontally to bring airflow across the refrigerant coils of the outdoor unit (see Figure 2 above). They have a slim profile, work well with narrow lots or where space constraints exist, and often have a lower cost compared to similar equipment with vertical fans. Due to their slim profile, these also are referred to as mini-split systems (outdoor compressor split from the indoor unit). Historically, these were only paired with ductless systems. Many of these units are now made specifically for ducted applications. One downside of this equipment category is that the outdoor unit has a smaller surface area for the refrigerant coil, and so have a more difficult time reaching high peak cooling efficiency (i.e., EER2). Some efficiency programs motivated by peak cooling savings may exclude some of these types of units. However, within the cold climate and variable speed category (discussed below), due to their mid-tier price point, manufacturers focus on these units and they have experienced a large uptick in sales in Minnesota.

Vertical fan ASHPs. These units have a fan oriented vertically to bring airflow across the refrigerant coils of the outdoor unit (see Figure 3 above). Besides their elevation above snow and being placed on a stand, they are similar in appearance to a traditional CAC cube style unit. Because of the high surface area on the refrigerant coils, many of these units have a higher peak cooling efficiency. Snowfall can occasionally create problems with the fan if the unit isn't protected and cleaned off appropriately or isn't running during a high snowfall event. There is a range of cost within this product category ranging from low for single-stage units to high for cold climate, variable speed products. Due to the size of these units and the premium price at the cold climate level, these units do not sell as quickly as some cold climate side discharge fan models.

Compressor Type and Cold Climate Capability

Single-stage ASHPs. These products have been in the Minnesota market for decades and predate variable speed ASHP products. They are typically installed in a centrally ducted application. These units are noisier compared to other compressor types below and only run at one speed. They do not have some of the added comfort benefits or better dehumidification that can be achieved through multistage operation or running at variable speeds. Conversely, they are less costly than higher performance ASHP units and may be an easier upsell compared to a low-end AC unit. They also typically have a higher cooling efficiency at high temperatures — which often coincide with the electric grid's summer peak times — especially compared to side discharge, variable speed units.

Two-stage or multistage ASHPs. These units have multiple speeds that allow them to have longer runtimes at different outdoor air temperatures, reducing equipment short cycling and providing better dehumidification benefits. These units have higher energy savings compared to single-stage ASHPs and can better dehumidify due to the existence of multiple speeds. They are not truly variable speed products, as they are not inverter-driven and are limited to fixed speeds within each stage of operation. Their cost typically falls between single-stage and variable speed equipment.

Variable speed ASHPs. These units' compressors are inverter driven, which allows them to modulate the compressor speed to match the home's heating or cooling load, similarly offering longer runtimes at various outdoor air temperatures. This is the most efficient product category for ASHPs and within this product category there is a range of efficiency and cold climate capabilities. Not all variable speed products are cold climate rated, as some may not meet specification requirements such as being 175% efficient (i.e., 1.75 coefficient of performance or COP) at 5°F outdoor air temperature.

Cold climate ASHPs. There are varying definitions of cold climate ASHPs and specification bodies within this category. These typically have an efficiency requirement to have a COP of 1.75 at 5°F, meet certain HSPF2 (heating efficiency) or SEER2 (cooling efficiency) metrics, and sometimes have a capacity maintenance requirement, which means the equipment's ability to maintain the amount of heat delivered as the outdoor air temperature gets colder compared to a benchmark such as 47°F.

Efficiency Specifications

Below is a summary of various product specifications for ducted and ductless ASHP products. The current utility rebate requirements in MN often reference these (e.g., federal minimum standard, ENERGY STAR, or NEEP) or will have custom requirements based on individual utility's goals such as summer or winter peak load mitigation.[10] The lowest possible standard for new ASHP equipment is the 2023 Federal Minimum Standard. Historically, the best available specification for cold climate ASHPs was the NEEP specification. As this cold climate equipment category grows, specification and product development advances. For example, ENERGY STAR Cold Climate was introduced in ENERGY STAR v.6.1 in January 2022.[11] The passage of the Inflation Reduction Act (IRA) in 2022 points to the "highest tier" as defined by the Consortium for Energy Efficiency,[12] which has similar requirements as ENERGY STAR Cold Climate, but also includes an EER2 requirement and an option for capacity maintenance for products that have not been tested at 5°F. The DOE Residential Cold Climate Heat Pump Technology Challenge is promoting the latest generation of cold climate equipment. Multiple manufacturers have met the requirements for this challenge and are currently field testing this equipment — stakeholders expect that equipment will be market ready in 2024.[13]

[10] MN ASHP Collaborative, "Incentives and Financing." Available here.

[11] Energy Star, "Central Air Conditioner and Air Source Heat Pump Specification Version 6." Available here.

[12] Congress.gov, "Inflation Reduction Act of 2022." Available here.

Table 1. ASHP Specification Summary

System type (ducted/ductless)	Specification	HSPF2	SEER2	EER2	COP @5°F	Capacity maintenance: 5°F / 47°F	Capacity maintenance: 17°F / 47°F
Both	2023 Federal Minimum Standard (North)	7.5	14.3				
Both	ENERGY STAR v6.1	7.8	15.2	11.7			
Both	DOE Cold Climate Heat Pump Challenge (5°F)[13]	8.5	14.3		2.4	100%	
Ducted	ENERGY STAR Cold Climate v6.1	8.1	15.2		1.75	70%	
Ducted	Consortium for Energy Efficiency Tier 1, North (qualifies for 25C tax credit)[14]	8.1	15.2	10.0	1.75	70% **or**	58%
Ducted	NEEP v4.0	7.7	14.3		1.75		
Ductless	ENERGY STAR Cold Climate v6.1	8.5	15.2		1.75	70%	
Ductless	Consortium for Energy Efficiency Tier 2, North (qualifies IRA 25C tax credit)[14]	9.5	16.0	9.0	1.75	70% **or**	58%
Ductless	NEEP v4.0	8.5	15.0		1.75		

Competitive landscape

For this initiative's focus to advance in the market, it needs to displace its primary competition which includes the following.

- New, centrally ducted furnaces installed with a paired CAC system
- Standalone, CAC system replacement
- New installation (if cooling was not formerly installed)

[13] U.S. Department of Energy, "Residential Cold-Climate Heat Pump Technology Challenge Specification" (2021). Available here. Products within this challenge are not yet in the market. Units larger than four tons have a COP requirement of 2.1. There are other requirements for this specification not listed on this table, such as a low GWP refrigerant and compressor cut in and cut out temperature requirements.

[14] Models that have not yet tested to Appendix M1 but have equivalent or higher tested Appendix M values still qualify as meeting CEE Tiers, per the approved crosswalk methodology.

In addition to the baseline technologies discussed above, there are also emerging technologies that could be appropriate in this application type. Table 2 below compares baseline and emerging technologies to ASHP technology. These technologies are discussed in further detail in Appendix A – ASHP Market Characterization Report in the Competing options section.

Table 2. Competitive products and characteristics

Competitive product, practice, or service	Commercially available?	Comparable cost (without consideration of incentives)	Energy savings	Comments/notes
New natural gas, electric, or propane furnaces paired with CAC	Yes	Lower	Lower	Historically lowest cost option and most widely sold (esp. natural gas and propane applications)
Ground source heat pump	Yes	Higher	Higher	Prohibitively expensive for most residential applications
Absorption heat pumps	No / minimal	Unknown	Lower	Product is not widely commercially available and value proposition is weaker

Market Description

Target market

The target market is the primary area of focus for the initiative. Table 3 below shows some general aspects of the target market for this technology including the sectors of focus for the ETA initiative, whether the initiative will focus on existing buildings, new construction or both, the current market size, and energy savings potential to provide a sense of opportunity scale.

Table 3. ASHP target market summary

Sector (e.g., residential, commercial, industrial, etc.)	Residential
Existing buildings and/or new construction	Existing buildings (planned and emergency replacements)
Current market size	Homes w/ natural gas furnace + CAC: 1,000,000 Homes with propane furnace: ~140,000

Technical savings potential	-4,170,000 MWh 45,600,000 Dth 31,400,000 net MMBtu

Market dynamics and path to purchase

ASHPs typically follow the traditional HVAC supply chain. At the beginning of the supply chain are manufacturers, who develop concepts, produce products, and fulfill distributor orders. These distributors provide products to contractors who in turn install them in customers' homes, working directly with the customer or with a builder in new construction projects. Some products are sold directly to customers via retailers, but this portion of the market is relatively small.

Figure 4. Traditional ASHP path to purchase

Contractors and customers embody the largest barriers and friction points related to increasing adoption of the technology. The CAC market is driven by emergency replacements, meaning that existing AC units either fail at end of life or significantly malfunction, thus triggering replacement. This emergency replacement scenario restricts the purchasing process because customers have a limited amount of time to replace their system, making them less likely to consider alternatives, more price sensitive, and less willing to go against contractors who may be more likely to stick with standard CAC technologies.

Contractors are a key market actor, as they are a trusted source of information for consumers, can influence customer choice, and can help customers navigate rebates at the point of purchase. Contractor buy-in, technical proficiency, and appropriate business strategy will be critical for the market adoption of ASHPs. Contractors also influence system design, installation quality, and customer education.

Additionally, there are big box and online retail channels that are emerging and could be the focus of future research efforts to better understand current market dynamics and opportunities in these alternative product pathways. Further detail about market actor roles can be found in Appendix A.

PROGRAM LOGIC

Long-term vision

The ASHP initiative will implement several strategic market activities with the initiative's desired end state in mind. If successful, contractors will report familiarity with ASHPs and be well versed in the value proposition offered by the product; customers will be able to easily find, engage, and solicit bids from qualified contractors; manufacturers, distributors, and programs will offer training and marketing in support of ASHPs; customers will be aware of ASHPs and their benefits; the supply chain will increasingly stock, promote, sell, and install ASHP systems; manufacturers will offer increasingly efficient and cold climate capable ASHPs; contractors will increasingly implement sales, design, and installation best practices; utilities will offer ASHP demand response programs or programs supportive of ASHPs; and the market share for ASHPs will increase. The desired end state of the ASHP initiative is to have a code or standard in place by 2035 to make ASHPs, rather than CACs, the standard choice for home heating and cooling. Our robust market support strategies will accelerate the market shift to achieve this goal.

Market barriers and opportunities

Multiple barriers inhibit the adoption of this technology. However, a few significant opportunities can help overcome the obstacles these products face. In this section of the market transformation plan, we distilled the key and most pronounced barriers and opportunities to build a successful strategy that will take these market dynamics into account. Program strategies will either be designed to overcome the most critical barriers listed below or leverage the opportunities identified to help the market catch wind faster. Further detail on these barriers and opportunities can be found in Appendix A.

Key barriers:

1. Undefined or weak value proposition

The value proposition (i.e., why should I purchase a heat pump?) is unclear to the supply chain, which includes customers, contractors, distributors, and manufacturers. This includes first cost challenges and other aspects. Operating costs savings may be minimally positive, negative, or neutral, which are broken out specifically and discussed further below. Avoiding carbon emissions motivates some customers but not all. Concepts like fuel choice flexibility and the comfort provided by variable speed products need more time and consistency in the market to become ubiquitous, recognizable features. Initial cost is a key challenge. Cost challenges include both more costly equipment and higher installation or soft costs. While system components are mostly comparable to AC products, some contractors may still hesitate to install heat pumps due to a perceived business risk of adopting a nascent technology and the potential for being called back on site by the customer. This perception may increase labor costs and make heat pumps disproportionately more expensive compared to a similar AC product. Off peak or dual fuel utility rates are available that offer low costs of electricity in exchange for the utility's ability to eliminate electric load during times of grid constraints. However, these lower operating costs may be impractical due to high costs associated with installing a second meter to serve this dedicated load. Due to these challenges with the value proposition for contractors and customers, less demand for the products is placed on manufacturers and distributors.

2. Lack of contractor and customer awareness and experience

While there is evidence of more familiarity with ASHPs, both contractors and customers have reticence or mistrust about the technology's applicability and performance in Minnesota's cold climate or in areas served by natural gas as the primary heating fuel. In addition, some contractors are less familiar with or lack the resources to install the equipment properly for each application, especially all-electric application types where ductwork assessments, load calculations, switchover temperatures, cost optimization, and equipment selection are paramount for quality installations.

3. Potential for higher operating costs compared to other fuel types, namely natural gas

Natural gas is much cheaper than electricity per energy unit in Minnesota and throughout the U.S. (e.g., dollars per Btu).[15] The ways in which these fuel price differences interact with operating costs over time is complex.[16] At present, the cost savings often aren't compelling enough to justify the higher initial cost without incentives. Even with modest savings, these may not amount to enough to justify the complexity and decision to choose an alternative over the status quo (furnace and AC). Furthermore, within this barrier is a sub-barrier in that many inverter-driven ASHPs are incompatible or do not work well with direct load control demand response programs, making it more challenging to enroll in cost competitive rates.

4. Inconsistent incentive designs and product specifications across utility, state, and federal offerings

This challenge rests with the wide variety of specification requirements within rebate programs. The MN ASHP Collaborative tracks these requirements and created a resource to help customers and contractors navigate them.[17] For example, users who download the utility rebate data will find 175 rows of varying incentives and requirements (e.g., SEER and HSPF ratings). An added complication is forthcoming rebates and incentives enabled by the Inflation Reduction Act and state-funded rebates, which are discussed in the opportunities section. Distributors need help prioritizing and navigating these requirements for purchasing decisions and

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[15] U.S. Energy Information Administration, "Minnesota State Energy Profile" (August 2023). Available here.

[16] MN ASHP Collaborative, "Cost of Heat Comparison Resources." Available here. Operating prices depend on equipment efficiency at different ambient outdoor temperatures and commissioning settings such as the switchover from an ASHP to a secondary heat source.

[17] MN ASHP Collaborative, "Incentives and Financing." Available here.

contractors need clarity for selling equipment and rebates to customers. Coordination is needed to limit the amount of variability to obtain for rebates and to ensure products qualify for rebate requirements.

Key opportunities:

1. Growing motivation to reduce carbon emissions and shift to cleaner heating alternatives

Various market actors are expressing a stronger drive to reduce emissions and use cleaner heating alternatives. Customers, utilities, and manufacturers are seeking to have a positive impact and meet environmental, social, and governance (ESG) requirements, as well as federal, state, and municipal governments. Globally, the war in Ukraine and the tenuous reliance on Russian natural gas in Europe is motivating high growth rates of heat pump sales.[18] Moreover, the U.S. is now an important player in the global liquified natural gas market, which impacts domestic natural gas markets.[19] The growth of heat pump products in Europe supports 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.[20] In addition, the Inflation Reduction Act provides funding mechanisms for customers through multiple avenues such as federal tax credits (25C and 45L) and home energy rebates: Home Efficiency Rebates (HER) and the Home Electrification and Appliance Rebates (HEAR). The $2,000 tax credit is available from 2023 through 2032. The HER and HEAR rebate programs will offer incentives up to $8,000 dollars for qualifying equipment and households.[21] In addition, Minnesota passed legislation that will provide an additional $4,000 per heat pump installation for qualifying households.[22] Lastly, the passage of the bipartisan ECO Act in 2021 allows MN electric and gas utilities to support fuel switching to meet certain requirements.[23] This may allow additional rebates for customers hoping to install ASHPs via utility programs starting in 2024. These funding mechanisms will motivate customers to choose heat pumps instead of ACs.

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

[19] Laurent Lambert, Jad Tayah, Caroline Lee-Schmid, Monged Abdallah, Ismail Abdallah, Abdalftah Ali, Suhail Esmail, and Waleed Ahmed, "The E.U.'s natural gas Cold War and diversification challenges" (September 2022). Available here.

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

[21] U.S. Office of State and Community Energy Programs, "Home Energy Rebates FAQs." Available here.

[22] Minnesota Legislature, "HF 2310." Available here.

[23] Minnesota Legislature, "HF 164." Available here.

2. Fuel flexibility enables cost savings and resiliency opportunities for both customers and utilities

Some utilities in Minnesota have successfully operated dual fuel rate programs for many years with ASHPs. This is a form of demand response where a customer agrees to have their equipment controlled during certain periods of the year in exchange for a lower volumetric electric rate. When the utility controls the customer's ASHP, it switches from using the ASHP as the primary source of heat to a secondary heating source such as a fossil fuel furnace. This reduces customer bills, creates a positive load factor for the utility, and reduces the need to build additional power plant capacity during times of peak grid demand.

3. State and federal codes and standards could be used as a lever to create mandatory, long-lasting change

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.

Market support strategies

To leverage the opportunities that exist in the market and overcome known barriers, we identified several strategic interventions. Many are informed by CEE's previous efforts and the MN ASHP Collaborative's years of experience working in Minnesota before the launch of ETA.

As the team embarks on market support strategies, more intelligence about the market will be gained, the impact of the strategies will become better known and the market itself may evolve or shift. In order to optimize impact of the initiative, the team will adapt and potentially shift market support strategies over time. These changes will be carefully considered, documented and brought to the coordinating committee on an annual basis.

1. Build contractor champions

This strategy will address the barrier of contractor awareness and experience. Ultimately, we want to cultivate a network of HVAC contractors that are qualified, committed, and supportive of ASHP technology, so customers receive consistent high-quality service and installations to meet the full energy savings and decarbonization potential of ASHPs. There are two main components to the contractor strategy:

- The first includes training content and tools/resources for contractors to support their journey to becoming a heat pump expert. The training and tools would be created and delivered in collaboration with utilities, distributors, and manufacturers and begin with applications with the highest value proposition. Topics and areas of focus will include tools, sales, and installation best practices to improve quality, efficiency, and business case. These may include resources to communicate the value proposition of ASHPs to customers, aggregation of resources to support time optimized, high-quality installations, or tools to facilitate proper system commissioning at the time of installation.

- The next step in this strategy is to differentiate the ASHP champions by ensuring a network and badge exists to highlight contractors that are committed, qualified, and supportive of ASHPs. This list should be highly vetted and include ample assurance that customers will have a positive ASHP bidding and installation experience. Additionally, this list should be leveraged by utility and state rebate programs to provide additional motivation for contractors to obtain this credential. This strategy could also involve championing the work of successful and high-quality contractors by highlighting and publicizing their work. By cultivating a network of highly dedicated contractors, thereby improving customer experiences and outcomes, this will ensure that early customer interest leads to a virtuous cycle of positive experience and word of mouth to strengthen the market's push and pull.

2. Drive customer awareness through resources and collaboration

This support strategy is two pronged and the first includes comprehensive assessment and development of tools and resources that can be leveraged by program stakeholders, such as local and state governments, utilities, and manufacturers. This could entail messaging research, a key messaging matrix, image library, a brand-neutral resource library, etc. This may also include an awareness campaign with materials created and delivered to the stakeholders mentioned. The second prong in this strategy involves the collaboration and dissemination of messaging and resources to program partners. The team will aim to be a nexus or hub of collaboration and coordination related to customer awareness. More specifically, this effort also aims to increase equitable ASHP adoption by specifically engaging with MN Department of Commerce staff involved in weatherization program delivery, affordable housing builders, community action partnership agencies, weatherization assistance program providers, and IRA low- and moderate-income program offering development and deployment.

3. Facilitate alignment among financing and incentive programs

This strategy will primarily aim to reduce costs for customers and contractors. It will focus on reducing market confusion from inconsistent incentive designs and may include providing facilitation support to state and utility rebate program administrators and organizations offering financing to simplify program requirements and coalesce around common goals. We will focus on streamlining the contractor and customer journey through these purchasing pathways. Furthermore, we will lower ASHP installation costs through a variety of means such as combining with other upgrades, controls, or financing and incentives. Focus will be paid to educating customers about these opportunities and ensuring equitable access to programs across market rate and income eligible populations.

4. Work with distributors and manufacturers to encourage appropriate stocking and promotion

Due to the replace on fail nature of HVAC, ready availability of ASHPs to enable rapid installation is essential. We will work with distributors and manufacturers to promote stocking models most likely to be specified. Distributors need to have ample insight into program requirements well in advance of new programs or program modifications to ensure the availability of products that meet incentive requirements. By building on existing market relationships and bidirectional communication with manufacturers and distributors, we can promote the availability of ASHPs and expedite their replacement of AC systems in emergency scenarios.

5. Collaborate with utilities and regulators on new rates and demand response programs

As relative operational costs are a primary barrier for this product, this strategy would include building awareness of new rates methodologies and communicating these approaches to utilities and regulators, as well as supporting dual fuel rates proposals through analysis and comments. This strategy may include a focus on electric heat and dual fuel rates that appropriately account for the true costs of dual fuel ASHPs[24] as well as understanding and supporting potential future impacts on natural gas rates. By encouraging more cost-competitive electric rates and also tracking future impacts and opportunities related to natural gas rates, the operational costs and potential customer cost savings would improve and strengthen the value proposition for customers with existing natural gas heat. Additionally, this could encourage a lower switchover temperature to a secondary heating system, which improves the energy and carbon savings potential over the system's lifetime. Moreover, appropriate rates ensure equitable access to heating electrification for customers with lower incomes that may spend a higher proportion of their income on energy bills.

6. Support product development and utility program development to enable demand response programs

Similarly aimed at addressing operational cost barriers, and as mentioned above, Minnesota electric cooperatives have successfully operated dual fuel electric rate programs that support ASHPs over traditional choices such as propane or natural gas furnaces. Dual fuel electric rates encourage a lower switchover temperature to the secondary heating system, enabling more electric heat and future carbon savings. However, barriers exist to enroll in dual fuel electric rates in some utility territories. These programs typically require a second meter, which is often

[24] Electric rates are composed of variable (generation or kWh) and fixed costs (transmission, distribution, capacity or kW, and customer billing). Rates seek to recover costs for variable and fixed costs to serve the customer. However, dual fuel ASHPs do not increase, or only moderately increase, fixed costs on the system. Only variable costs increase compared to the typical residential customer.

prohibitively expensive to install depending on the utility. If a service line was previously buried, the price is much higher. Moreover, some variable speed ASHP units are incompatible with traditional direct load control programs, which prevents enrolling in these programs. Solutions are being tested in the field but are not widespread. We will provide support and advocacy to both manufacturers developing solutions to alleviate these barriers and utilities offering novel solutions.

7. Influence state or federal code, policy, or appliance standard to encourage ASHPs in place of ACs

As this initiative is a dual fuel strategy, an appropriate state or federal code or policy could include developing a regulation or incentive to encourage ASHPs over ACs. This could limit equipment shipped to MN without a reversing valve (i.e., a heat pump) or policy supporting incentives to manufacturers to discontinue the production of ACs.[25] These ideas may be interim steps within this strategy toward this initiative's end goal to have a code or standard in place to make ASHPs instead of ACs the standard choice for home heating and cooling by 2035.

PARTNERS AND ROLES

For this work, CEE plans to build partnerships with local and national stakeholders to establish a trusted voice in the market and influence change.

Utility stakeholders

Minnesota utilities funding the Minnesota Efficient Technology Accelerator (ETA) are key stakeholders that serve on the ETA Coordinating Committee. Representatives of these utilities are also invited to serve on the Evaluation and Cost-Effectiveness Advisory Committee and the Market Strategy Advisory Committee. These utilities include:

- Xcel Energy
- Minnesota Power
- Otter Tail Power
- CenterPoint Energy
- Minnesota Energy Resources

Since this initiative technology is part of the natural gas and electricity markets, a collaborative partnership will yield beneficial outcomes for all involved.

CEE is working with each of these utilities to develop cost-effectiveness calculations; provide savings and cost information; gather, aggregate, and report rebate participation data; deliver

[25] Congress.gov, "HEATR Act" (2022). Available here. An example of an incentive to encourage manufacturers to forgo making or selling ACs is the HEATR Act, which was introduced in May 2022.

contractor training and build a qualified contractor network; and, as much as possible, align and standardize program offerings throughout the state.

CEE is also working with other utilities to broaden the impacts of this work. In 2019, CEE launched the Minnesota Air Source Heat Pump Collaborative. This was a precursor to the dual fuel ASHP initiative outlined herein, with a mission to make ASHPs the first choice for customers. This effort included developing a contractor- and homeowner-facing website, ASHP rebate program data aggregation and reporting, resources for switchover temperature selection and cost of heat comparisons, on-demand training modules, the development of a preferred contractor network for qualified ASHP contractors, and a variety of resources for the primary audience to help with installation or shopping for a heat pump. The following utilities primarily funded the program:

- Great River Energy (GRE)
- Minnesota Power
- Otter Tail Power
- Southern Minnesota Municipal Power Agency (SMMPA)
- Missouri River Energy Services (MRES)

CEE continues to work with the above utilities to deliver the legacy efforts of the MN ASHP Collaborative. In addition, CEE has worked with Xcel Energy and Minnkota Power Cooperative on touch points such as research dissemination and contractor training. As a statewide program, ETA will continue to work with utilities throughout the state with the common goal of promoting ASHPs.

With the launch of ETA, the consumer-owned utilities mentioned above (GRE, SMMPA, and MRES) have opted to continue to fund the MN ASHP Collaborative. In addition, CEE continues to work with Minnkota Power Cooperative on delivering contractor training events. All market support activities implemented through ETA will be channeled through the recognizable brand of the MN ASHP Collaborative. This approach will leverage existing program success and relationships. The involvement of ETA utility funders and opt-in funders will bolster the success of this initiative.

NEEA

CEE began working with NEEA on ASHP-related research in 2020 and leverages their extensive experience with market transformation and their ductless heat pump initiative to inform logic model development for this initiative.[26] Capitalizing on over 25 years of experience with market transformation, CEE will work closely with NEEA to strategically prioritize and align engagement with manufacturers when needed to advance this initiative's goals.

[26] NEEA, "Variable Speed Heat Pump Product Assessment and Analysis" (April 2022). Available here.

National Partnerships and Stakeholders

CEE, through research efforts spanning back to the previous decade and those of the MN ASHP Collaborative, engages with a variety of national groups focused on several aspects of ASHP market development. Below is a summary of each group and CEE's involvement.

- **Consortium for Energy Efficiency** is a nonprofit that sets the efficiency standards for the 25C ASHP tax credit as well as other efficiency tiers for equipment for their utility membership (e.g., advanced tier). Historically, CEE engaged with this organization to elevate industry questions and concerns related to the tax credit, and the team will continue to track, monitor, and collaborate with the Consortium's role in the ASHP market. Official membership will be considered in 2024. This will benefit this initiative by engaging with manufacturers and program administrators to stay attuned to market trends and establish relationships that support market support strategies.
- **The Advanced Heat Pump Coalition** is convened by the Midwest Energy Efficiency Alliance. This group comprises a variety of working groups, with the most active group centered on test procedures and ratings. Meetings center on ongoing field studies and standards such as the load-based rating, CSA SPE-07:23. Outcomes of this group may inform future utility rebate specifications, which are based on equipment energy use and performance.
- **Northeast Energy Efficiency Partnerships** is a nonprofit composed of funding members in the northeast as well as national-level subscribers. CEE is an annual subscriber, which provides access to working groups and the back-end data for the qualified products list for NEEP's cold climate ASHP database. CEE leverages the Sizing for Heating tool in contractor training materials as a resource for equipment selection. In addition to advocating for tool updates and modifications, CEE participates in the following workgroups.
    - Residential Heating Electrification Working Group
    - Cold Climate ASHP Specification Committee
    - Installer Best Practices Committee
- **CLASP** is a nonprofit organization focused on sustainability and improving energy efficiency of everyday appliances and equipment. CLASP led a national-level research study focused on the benefits of dual fuel ASHPs in place of ACs and interacts with policy initiatives at a federal level. CEE participates in CLASP stakeholder meetings (Hybrid Heat Coordination Group) and is a cosignatory on a few filed comments to federal agencies, such as the proposal to sunset CACs from the ENERGY STAR program in favor of ASHPs. CLASP could be a key stakeholder leveraged to influence change in model building code or appliance standards at the federal level.

Savings Potential

This initiative has significant savings potential. Technical potential represents the total achievable savings if we were able to influence the market to a maximum effect. The estimated total technical potential for the ASHP initiative is 4.17 million megawatt hours (MWh) and 45.6 million dekatherms (Dth) or 31.4 million MMBtu (million British thermal units) for combined savings.

To project technical potential, we first identified per-unit savings values using Appendix G[27] of the Minnesota TRM (version 4.0). We leveraged the default inputs included in Appendix G and modified the product specification inputs, outlined in the table below, to align with our product definitions (Table 2). The listed product specifications were converted from M1 to M format for input into Appendix G,[28] and the climate-zone specific outputs were converted into one load-weighted average value based on the proportion of buildings in each climate zone. This resulted in a net ASHP per-unit savings of 25 MMBtu for Tier 1 ASHPs and 43 MMBtu for Tier 2 ASHPs.

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[27] MN Commerce Department, "Technical Reference Manual." Available here.

[28] Consortium for Energy Efficiency, "Program Resources." Available here. This was accomplished using the conversion method in the MN Technical Reference Manual 4.0, which differs from the recommendations from AHRI.

Table 4. Product specification inputs for Appendix G

Tier	Specification aligns to:	Switchover (°F)	For homes with this fuel type:	HSPF2	SEER2 (HP)	SEER2 (AC)
1	Federal minimum	30	Natural gas	7.5	14.3	13.4
2	25C tax credit requirement	15	Propane	8.1	15.2	--

These per-unit savings were then applied to existing building stock data from RECS2020[29,30] to estimate the technical potential. This includes all centrally ducted homes with CAC and natural gas heat (1,000,000 homes) and all centrally ducted homes with CAC and propane heat in Minnesota (140,000 homes), resulting in a technical potential of 31.4 million MMBtu (Table 5). To calculate the technical potential, we assumed that Tier 1 products would go into natural gas-heated homes, and Tier 2 products would go into propane-heated homes as propane is more expensive and justifies a higher product cost. This is a conservative savings approach because we anticipate that some Tier 2 products will be used in natural gas-heated homes.

Table 5. ASHP Technical Potential

	Electric (MWh)	Gas (Dth)	Combined (Net MMBtu)
Statewide Technical Potential	**-4,170,000**	**45,600,000**	**31,400,000**
Gas Heated Homes	-3,300,000	36,600,000	25,400,000
Propane Heated Homes	-870,000	9,000,000	6,000,000

Further detail and context for energy savings estimates can be found in Appendix B.

RISK MITIGATION PLAN

Risks are inherent to any project. However, we have identified key anticipated risks and developed mitigation strategies. These are described in Table 6 below.

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[29] U.S. Energy Information Administration, "2020 RECS Survey Data." Available here.

[30] Ibid. A similar estimate was conducted for the Minnesota Energy Efficiency Potential Study published in 2018. The RECS data are newer than the data used in the potential study and have a larger sample size in this iteration allowing for state-by-state analysis.

Table 6. ASHP risk mitigation matrix

"IF" this happens	"THEN" this will occur (impact)	Probability (H/M/L)	Impact(H/M/L)	Risk response: (Accept, avoid, mitigate, transfer)	Response plan
Natural gas costs[31] return to pre-pandemic levels and remain low relative to heating with an ASHP.	Contractors and customers may hesitate to recognize the full value proposition for ASHPs if conventional heating solutions remain less costly to operate.	M	H	Mitigate	Continue to work with MN electric utilities on dual fuel electric rates to appropriately charge for ASHP electric use.
Contractors increase the price of installation costs disproportionately compared to ACs after recognizing the incentives available for ASHPs through state and federal funded statewide rebates and utility programs.	Customers may hesitate to recognize the full value proposition for ASHPs if conventional heating systems are lower or similar cost to operate and have a lower initial cost.	M	M	Mitigate	Beyond incentives, work with rebate program staff to explore setting price caps or requiring documentation of costs for ASHPs on customer invoices or rebate forms.
Federal tax credits, utility, and statewide rebates do not adequately support ASHP product tiers to incentivize customers to choose ASHPs instead of ACs.	Customers may hesitate to recognize the full value proposition for ASHPs if conventional heating systems are lower or similar cost.	L	H	Mitigate	Continue to gather price data through the aggregation of bids, secret shoppers, or other methods to track incremental costs compared to rebate amounts.

[31] Natural gas costs are influenced by a variety of complex factors and are difficult to predict. These include increased U.S. liquid natural gas (LNG) export capability and resulting susceptibility to global natural gas prices, the ongoing war in Ukraine, production capability in the U.S., utility regulation (e.g., the 2021 winter storm Uri), and natural disasters.

"IF" this happens	"THEN" this will occur (impact)	Probability (H/M/L)	Impact(H/M/L)	Risk response: (Accept, avoid, mitigate, transfer)	Response plan
Policy changes or reversals may reduce funding, programs, and levers aimed to increase ASHP adoption.	Uncertainty may occur in the market and lead to hesitancy for distributors to stock equipment and contractors to offer this to customers.	L	H	Mitigate	Investigate existing funds allocated to lower the initial cost of ASHP purchases and determine the likelihood of reversal. Leverage and promote funds and programs with stronger footing if any are at risk.

TRANSITION PLAN

The ASHP initiative team will track metrics to monitor the progress of the initiative and re-evaluate strategic interventions as necessary. The ASHP logic model will be updated periodically during the Market Development phase, removing barriers and opportunities based on the evolution of the market. Interventions will be adjusted to ensure sustained acceleration of market adoption, leading to the ultimate impact: by 2035, if the program is successful, a code or standard will be in place to supplant CACs with ASHPs as the standard choice for home heating and cooling.

Once the market development strategies have been deployed for multiple years and achieve their desired impact, the team will monitor market share, market progress indicators, and the code and standards landscape to determine the right time for the program to pull back market development activities. This will include transitioning critical functions to the market and a move into the Long-Term Monitoring and Tracking (LTMT) phase where sales will be tracked and analyzed to measure savings, but market support activities are discontinued. Determining readiness for transition from market development, a resource intensive phase, to LTMT, a resource light phase, will require careful monitoring and assessment to determine optimal timing. The ETA coordinating committee will review and approve the transition to LTMT.

Appendix A. Market Characterization Report

See ASHP Market Characterization Report.

Appendix B. Energy savings and market evaluation

See ASHP Energy Savings and Market Evaluation Plan (Includes complete logic model)