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Planning for Wisconsin Air Source Heat Pump Market Transformation

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EXECUTIVE SUMMARY

In 2019, Wisconsin became the first state in the Midwest to commit to being 100% carbon free by 2050. To decarbonize its grid faster and mitigate climate impacts, the state's building sector needs to accelerate the transition of heating loads from fossil fuels to beneficial electrification via air source heat pump (ASHP) adoption. Several market barriers prevent accelerated adoption, including operational cost increases compared to natural gas, contractor unfamiliarity, consumer unfamiliarity, lack of consumer demand and insufficient income-qualified program integration. The complexity and diversity of the ASHP product category, lack of contractor tools and knowledge to appropriately design systems, and suboptimal controls configurations present further barriers in product selection and performance. These issues are compounded by each specific sector having its own unique set of challenges such as multi-family versus single-family or new construction versus retrofits. Unless addressed, these barriers will result in slow adoption and create distributional inequities across populations.

The State of Wisconsin can achieve rapid, equitable adoption of heat pumps through a well-orchestrated set of programs, policies, and market interventions. State, utility, and community funded programs and policy design that use both traditional resource acquisition and market transformation methods can engage the entire supply chain and reshape the heat pump market landscape. Resource acquisition programs like Focus on Energy are generally considered to be utility rebate programs that offer customer incentives to upgrade to a higher efficiency option. Investments and savings are calculated on an annual basis. Market transformation methods are generally considered to look at a longer time horizon, invest upstream of utility rebate programs and can invest for energy savings and benefits years into the future. To be successful, this initiative must be collaborative and state-wide. However, the status quo on utility heat pump program interventions is fragmented and insufficient to the task. Therefore, our team created a heat pump market transformation plan directed at all the industry stakeholders and supply chain actors who will actively transform Wisconsin's residential space heating market.

The project was led by three leading Midwest organizations with prominent expertise in cold-climate heating technology and state, utility, and community program design and implementation: Slipstream, Center for Energy and Environment (CEE), and Elevate (collectively the Project Team). The Project Team's collective effort will help pave the way for Wisconsin's rapid heat pump adoption as well as help to make the case for smart electrification and fuel switching policies. Taking this path will bring 2050 decarbonization commitments closer to realization.

To better understand the market context, we conducted analysis on Wisconsin's residential building landscape, engaged market actors, and conducted a stakeholder needs assessment. We defined screening criteria to identify five of the best near-term residential ASHP opportunities and conducted detailed economic and emissions modeling on each. The team aligned the market transformation goal with the regional Midwest ASHP Collaborative so that "ASHPs are the first choice for heating and cooling by contractors and customers by 2030" and defined a roadmap and playbook for how to get there with recommended actions for the State, Focus on Energy, utilities, and communities in Wisconsin.
Finally, our team disseminated the market transformation playbook to stakeholders and provided preliminary planning, technical, and analytical support to a few individual stakeholders as they began taking action to drive progress in the ASHP market.

GLOSSARY

Coefficient of Performance (COP): This is the ratio of cooling or heating output to energy consumed at a specific temperature. This ratio converts both output and consumption to a common unit, making this different than HSPF or SEER which use a ratio of BTUs to watt-hours. The higher the COP, the better. The higher the rating, the more efficient the unit.

Ductless mini-split: A ductless mini-split is a heat pump system where the outdoor compressor is typically smaller and has a fan that discharges to the side instead of the top. For whole home comfort, there may be multiple indoor units that connect to one outdoor unit. For homes that just need added comfort to one room/area, there will be one outdoor unit and one indoor unit in the room/area needing the added comfort. The outdoor compressor is sometimes referred to as a “suitcase compressor” as they are shaped more like a traditional suitcase, rather than a cube, like a traditional central air conditioner.

Single-stage/Two-stage ASHP: A single-stage heat pump only runs at 100% capacity and is limited to heat at moderate temperatures. A two-stage heat pump has two distinct stages of heating and cooling with typically a high capacity of 100% and low capacity of 70%.

Variable Speed ASHP: Also referred to as “variable capacity heat pump”, uses an inverter motor to allow for operation at multiple speeds (capacities).

Cold-climate ASHP: A cold-climate heat pump uses an inverter, or variable speed drive that has been tweaked to ensure greater ability to heat at lower outdoor temperatures. It also makes it capable of efficiently heating homes in colder climates with temperatures getting down to approximately -15°F. Different specific definitions exist but for purposes of this report we define a cold-climate heat pump as having COP of at least 1.75 at 5^{o}F while retaining maximum capacity.

Retrofit-ready variable speed heat pump: A growing product class of ASHPs that can retrofit onto existing forced air furnaces. and hold a rating based on an outdoor unit and indoor unit match, rather than outdoor unit, indoor unit, and furnace match.

Switchover temperature: The outdoor air temperature that the heat pump stops operating and backup heating system (natural gas or propane furnace) begins to operate, and visa versa (with backup heat operating at lower outdoor temperatures).

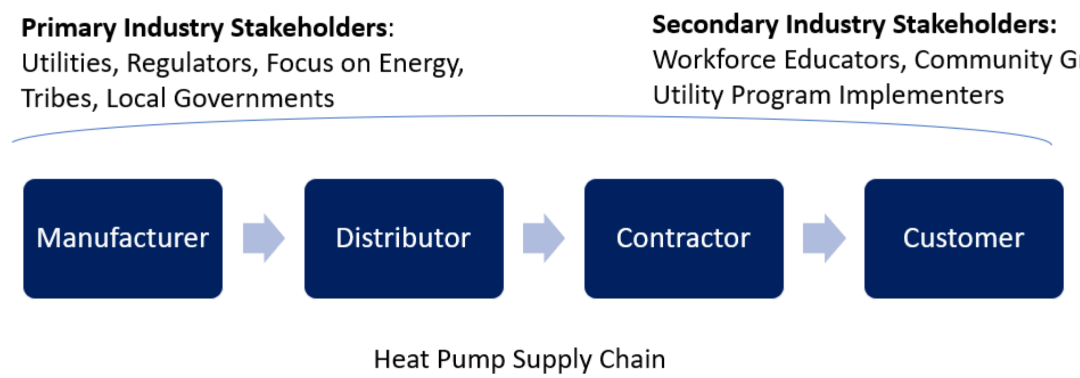
Economic switchover: Also known as economic balance point, the outdoor air temperature at which operation of the heat pump’s backup heating system would cost the same to run. The economic balance point is sensitive to electricity and backup fuel prices and the ability of the heat pump to maintain high efficiency at lower temperatures.

Bill parity temperature: We use this term to describe **t**he temperature where switchover from heat pump to backup system operation results in equivalent annual bills to the pre-installation period.

INTRODUCTION AND OBJECTIVES

Figure 1 below illustrates the heat pump supply chain and the key market actors including equipment manufacturers, distributors, and contractors. This project focused on engaging the supply chain and primary industry stakeholders.

Figure 1. ASHP supply chain and stakeholders



This project had the following objectives:

1. Engage with key actors in the Wisconsin heat pump market, including manufacturers, distributors, utilities, local governments, program designers/implementers, policymakers, and early adopting contractors.

2. Develop value propositions showing multiple applications where a case can be made that heat pumps save customers money in the long run.

3. Create a playbook that includes specific actions recommended to each of the primary industry stakeholders in terms of policies and programs in Wisconsin. Disseminate the written playbook to each key actor described in the first objective. Hold a presentation/webinar on the playbook for five primary industry stakeholder audiences.

4. Begin to provide analytical and technical support for three to five stakeholders who actively adopt the playbook to strengthen their decision-making surrounding market and program interventions.

What follows is a summary of project activities including findings from the stakeholder needs assessment, analysis of Wisconsin's residential building stock, analysis of the top ASHP opportunities, a defined roadmap for market transformation, recommended actions for primary stakeholders, and a summary of dissemination of the market transformation playbook and analytical and technical support to stakeholders.

NEEDS ASSESSMENT FINDINGS

Insights from market actors came primarily from the Wisconsin Heat Pump Coalition. This Coalition is an informal stakeholder group made up of heat pump manufacturers, distributors, local governments, Focus on Energy, and our team. The Coalition started meeting in 2021 and was an inspiring force behind this project. Since the project kicked off in August 2022, with our team's facilitation, the WI Heat Pump Coalition grew from approximately 30 members to 50 members and provided a valuable forum to bring together market actors and state and local leaders to engage and address timely barriers and opportunities for residential ASHPs.

In addition to ongoing engagement with the Wisconsin Heat Pump Coalition, our team interviewed a sample of state, Focus on Energy, utility, local community, and tribal representatives. Each interview included 1-5 individual representatives.

Table 1. Stakeholders interviewed

Stakeholder	Number of Interviews
State	2
Focus on Energy	1
Utility	4
Local government or community	6
Tribes	4

Each interview included questions on the stakeholder's perceptions of the ASHP market and what they saw as some of the biggest barriers and opportunities for ASHPs in Wisconsin. Table 2 below is a summary of identified barriers and opportunities by stakeholder type.

Table 2. Stakeholder identified ASHP barriers and opportunities

Stakeholder	Barriers	Opportunities
State	• Upfront and operational costs • Controls between electric baseboard and heat pumps • Lack of acceptance and poor perception among weatherization agency network and contractors • Management of experience for elderly populations • ASHPs more complex than furnaces	• Further staff education • Propane opportunity is mission critical • ASHPs address heat stress during summer months • Consider ASHPs alongside gas furnace • Customer guidance surrounding ASHPs and costs • Inflation Reduction Act programs • Management of weatherization agency contractor procurement
Focus on Energy	• Cost analysis is biggest struggle • Not positioned to lead charge on electrification • Equity concern regarding renter bill impacts • Contractor long memory and skepticism about ASHP performance	• Increased rebates • See communities leading charge on decarbonization/electrification messaging • Show savings to contractors and customers • Electrically heated customers as best economic opportunity

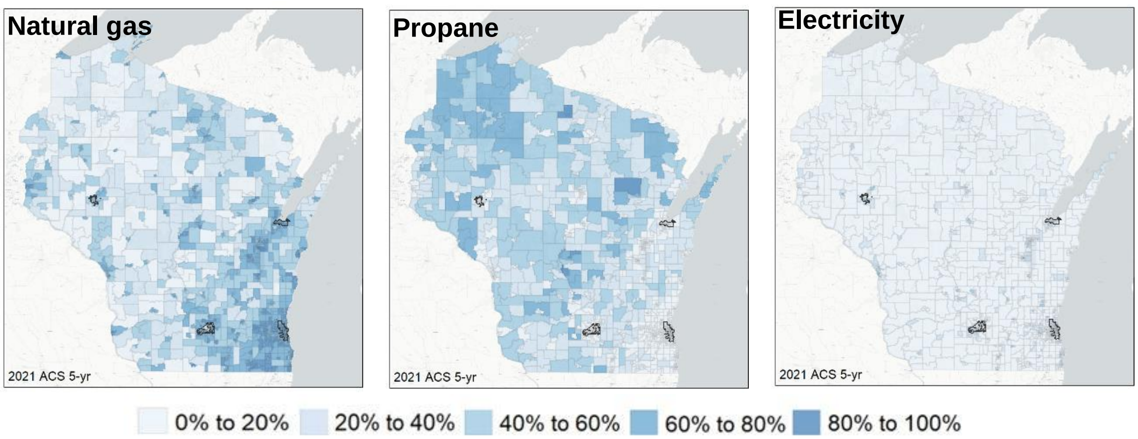
	• Inability to replace window AC units in multi-family buildings • Risk of poor installs and overpromising performance	• Common for homeowners to replace furnace and AC at the same time • Manufacturer and distributor training capacities
Utility	• Lack of own staff knowledge • Customer concern about ASHP ability to heat at coldest temperatures • Recognition of electric rates and clarity of energy/cost savings as barrier • Contractors and customers “waiting and seeing” for more guidance on IRA programs • Bill impacts for low-income customers	• Alignment with top ASHP opportunities the Project Team identified. • Demand response • Use advanced metering data to identify customers with high electric heating loads • See Focus on Energy needing to play role on training installers on how to work with customers
Local government or Community	• Limited financial resources local governments and communities have to wield • Upfront costs, including weatherization and electrical upgrades • Risk of increasing bills for low-income customers • Limited contractor awareness and lack of willingness to install ASHPs • Inability for Focus on Energy to claim heating savings from propane retrofits	• Federal funding opportunities for affordable housing • Host customer and/or contractor events on ASHPs • Track ASHP sales at statewide level to measure market progress. Take lessons learned from high-efficiency furnace market transformation in Wisconsin during 1980’s. • Facilitate and convene community and market actor stakeholders • Local governments want relationship with Focus on Energy like utilities have relationship with Focus on Energy to leverage programs and incentives
Tribal Housing Authorities	• Low awareness of heat pump technology • High cost to retrofit • Difficulty to find contractors in rural areas even with supportive manufacturers and distributors • New and different maintenance procedures • Reliability of heat pumps	• Interest in heat pumps to reduce carbon impact, add cooling, improve air quality • Demonstration projects to prove cold-temperature performance in their communities • Engage tenants • Focus groups with housing authorities to learn more • See housing authorities playing leadership role in improving their housing by bringing new technology like ASHPs to tribal reservations

WISCONSIN BUILDING STOCK ANALYSIS

Heat pump opportunities vary by the housing stock, existing heating fuel, and geography, among other factors. Segmenting opportunities and identifying applications with the best current feasibility is important to guide local communities and utilities where to focus heat pump efforts within their geography. Statewide data on Wisconsin’s housing stock, heating fuels, and mechanical systems were analyzed to identify heat pump opportunities by market segment.

At a high level, the majority (65%) of housing units in Wisconsin are heated with natural gas, followed by electric heat (18%) and propane heat (12%)[1]. However, concentrations of heating fuel vary by geography and housing type. Residential natural gas heating is concentrated in urban areas and southeast Wisconsin (Figure 2). In contrast, propane is concentrated in rural areas and northern Wisconsin. Electric heat (largely electric resistance) is more evenly distributed throughout the state – with most census tracts having between 10 – 20% electric heat. Conversion of existing natural gas, propane, and electric resistance heating to heat pumps are all important opportunities in Wisconsin; however specific communities may want initial heat pump retrofit programs to focus on heating fuel segments that are most prominent in their own community.

Figure 2. Percent heat fuel by census tract

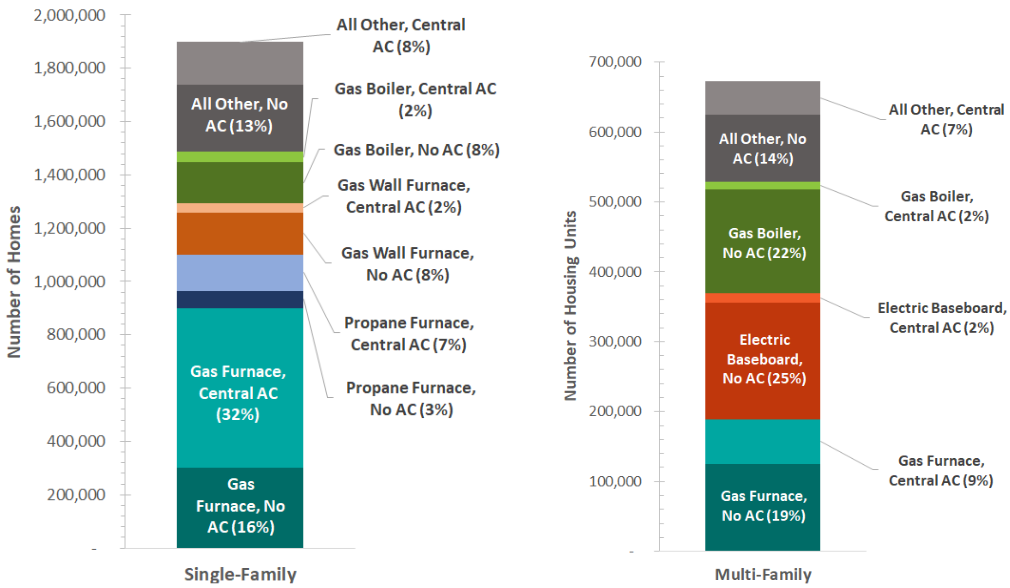


Heating and cooling system types across Wisconsin were also examined for single-family and multi-family units (Figure 3). A key takeaway from this analysis is existing combinations of heating and cooling systems vary widely across Wisconsin, particularly in the single-family housing segment. There is no one-size-fits-all approach for heat pumps; the variety of existing system types will many times require different heat pump solutions. This analysis can inform the most common system types to focus initial heat pump programs. In single-family homes, natural gas furnaces and propane furnaces are the most common, composing 48% and 10% of the single-family market, respectively. In multi-family units, heating systems are almost equally spread between gas furnaces (28%), electric baseboard (27%), and natural gas boilers (24%).

Importantly, access to central cooling is not common across all three of these heating system types; heat pump retrofits offer the added benefit of improved access to cooling. In the age of climate change and increasingly hot summers, access to air conditioning is emerging as a need in the Midwest – rather than an added amenity. Homes with an existing cooling system also represent a key market segment for increasing heat pump adoption in the short term by switching to a heat pump when a replacement is needed, as described in a 2021 report by CEE and Elevate.

[1] Source: American Community Survey (ACS) 2021 1-year data

Figure 3. Heating and cooling system types across Wisconsin by single and multi-family units[2]



Data on Wisconsin's new construction market was also assessed. More than 20,000 new construction residential units were constructed in 2022.

Table 3. Number of new construction units in 2022[3]

Unit Building Type	Number
1 unit	11,699
2 unit	1,296
3 and 4 unit	132
5+ unit	7,387
Total	20,514

This analysis of statewide data directly informed the value proposition development, described below.

DEFINING ASHP VALUE PROPOSITIONS

Value proposition is defined as innovation, service or features intended to make a product attractive to customers. Discovering and communicating value proposition for an emerging technology is a critical step in accelerating market adoption. By defining the value of the technology, this can be communicated

[2] Source: ResStock, 2018
[3] Source: US Census Building Permits Survey, 2022

to the supply chain and customers to ensure that the market push and pull is activated to benefit utility programs and achieve energy savings and carbon reduction.

Value proposition development was informed by the Wisconsin housing stock analysis, the Project Team's experience with heat pump implementation in Wisconsin, and discussions with distributors and manufacturers to understand the market landscape. The Project Team defined four criteria for prioritizing opportunities:

- **Carbon reduction potential**: Defined by the portion of a given market segment the opportunity could impact – and therefore able to scale carbon reductions or bring about a large carbon reduction on a per-unit basis (e.g., displacing or replacing existing heating fuel type results in relatively large carbon savings).

- **Customer economic benefit**: Defined by the positive impact the opportunity could have to reduce utility bills, lower upfront costs, and qualify for available incentives.

- **Equitable adoption**: Defined by how big of an impact an opportunity could have in communities with high energy burden, areas where there is a concentration of renters, and/or areas where tribes are located.

- **Building technology momentum**: Defined by the presence of macro trends that may favor the opportunity, a clear pathway to market readiness for the opportunity, and/or the existence of non-energy benefits to consumers within a given opportunity.

Based on the above criteria, the Project Team leveraged a robust brainstorming and strategic visioning process to rank an initial list of opportunities and selected the top five. The following five opportunities were identified with example descriptions:

1. **Single-family dual fuel natural gas displacement (AC replacement)**: A resident with a ducted natural gas furnace wishes to add or replace their central AC. They opt to add a ducted heat pump to partially offset their heating load, while also adding or replacing their AC.

2. **Single-family dual fuel propane displacement (AC replacement)**: A resident with a ducted propane furnace wishes to add or replace their central AC. They opt to add a ducted heat pump to partially offset their heating load, while also adding or replacing their AC.

3. **New construction – all electric single-family**: In a single-family home original design, it was going to be constructed with a ducted natural gas furnace and central AC. Instead, it is designed to be heated and cooled with a ductless mini-split and electric baseboard backup.

4. **New construction – all electric multi-family**: A new multi-family building was originally going to be constructed with central gas boiler heating and window unit AC. Instead, it is designed to be heated and cooled with ductless mini-splits.

5. **Multi-family electric resistance heat**: An owner of a multi-family building with electric resistance heat would like to add cooling. The owner opts to add a ductless heat pump to partially offset the heating load while also providing cooling to tenants.

After completing the market needs assessment, below is the Project Team's initial determination of how each opportunity performs across all four criteria in Wisconsin.

Table 4. Summary of selected opportunities scored by evaluation criteria

Opportunity	Carbon reduction	Customer economic benefit	Equitable adoption	Building technology momentum
Single-family dual fuel natural gas displacement (AC replacement)	High	Low	Low	High
Single-family dual fuel propane displacement (AC replacement)	High	High	Moderate	High
Single-family all-electric new construction	Low	Moderate	Low	High
Multi-family all-electric new construction	Low	Low	High	High
Multi-family electric resistance heat	Moderate	Moderate	High	High

The Project Team also worked with graduate students in a UW-Madison cost-benefit analysis class to examine the following additional ASHP opportunities that ranked high on the criteria listed above but represent heating systems that are less common in Wisconsin:

- Single-family homes with electric furnace heat and central A/C retrofitted with a ducted cold-climate heat pump
- Single-family homes with electric baseboard heat and window A/C retrofitted with ductless heat pump(s)
- Single-family homes with natural gas boiler heat and window A/C retrofitted with ductless heat pump(s)
- Single-family homes with wood heat and window A/C retrofitted with ductless heat pump(s)

Results of the UW-Madison students' cost-benefit analysis were published in December 2022 and are available online.[4]

METHODOLOGY

Following selection of the five ASHP opportunities with the best value proposition according to our screening criteria, we modeled the customer economics and carbon impact for each.

The Project Team used an hourly building energy conservation model developed in R, a programming language for statistical computing and graphics. The model requires information describing the HVAC system, building construction, weather, carbon emissions intensity, and energy prices. HVAC system information includes heating and cooling efficiency and capacity, modeling how these change with outdoor air temperature. The model also considers the effects of fan energy and required cubic feet per minute (CFM). Switchover temperatures are a key input for dual-fuel heat pump scenarios and are iterated to find the bill parity temperature where possible. All-electric systems are modeled to supplement heat pump operation with the backup heating system when it can no longer provide the whole building load. The resulting outputs are hourly load, HVAC energy consumption, fuel costs, and carbon emissions for a typical year's operation.

Statewide assumptions on fuel costs, emissions, and housing stock

The Project Team used 2022 average Wisconsin fuel costs. Future rate cases or price adjustments by Wisconsin utilities will change the price of electricity. Natural gas and propane prices are both tied to commodity prices, and subject to short- and long-term volatility. This analysis does not attempt to capture all possible regional and forecasted price mixes in the context of the scenarios but will note directional sensitivities where appropriate.

We used the NREL Cambium projections[5] for Wisconsin grid emissions across the next 15 years, in both a business-as-usual case for slow decarbonization and a high decarbonization case that assumes the grid is 95% decarbonized by 2050. Note that in both cases, this analysis assumes units are installed in 2023 and therefore starts with approximately 70% of electricity coming from fossil fuels. We levelized the emissions for each hour of the year, then projected the lifetime impact of baseline and electrification scenarios in each case. Under either scenario, installing the units later will result in reduced lifetime emissions, but the scope of this analysis is to assess the emissions impacts of near-term installations.

Table 5: Statewide assumptions on fuel costs and emissions

	Assumption	Value	Source
Fuel Costs	Electricity price	$.132/kWh[6]	Energy Information Administration (EIA) 2022 average

[4] https://lafollette.wisc.edu/research/air-source-heat-pumps-for-residential-space-heating-in-wisconsin-a-cost-benefit-analysis/

[5] https://www.nrel.gov/analysis/cambium.html

[6] We started with the average statewide bundled electric rate (fixed and volumetric charges) from EIA and subtracted out a population-weighted average fixed charge associated with each kWh based on rate information from the 5 Wisconsin dual-fuel utilities with largest electric customer counts.

	Propane price	$2.27/gallon	Energy Information Administration (EIA) 2022 average
	Natural Gas price	$.981/therm[7]	Energy Information Administration (EIA) 2022 average
Emissions	Electricity-95% decarbonized by 2050	Hourly emissions factor range: 141-413 kg CO2/MWh	NREL Cambium (2023-2037)
	Electricity mid-case	Hourly emissions factor range: 154-489 kg CO2/MWh	NREL Cambium (2023-2037)
	Propane	214 Equivalent kg CO2/MWh	Energy Information Administration (EIA)
	Natural gas	181 Equivalent kg CO2/MWh	Energy Information Administration (EIA)

ResStock data was summarized to find the median values for home age and size in the state, for each of the baseline home types in the scenarios. While existing and new construction multi-family units in our analysis differ only in building age, single-family units differ in both age and median square footage, as shown in Table 6. These values served as inputs to calculations for design loads for heating and cooling in the subsequent section.

Table 6: Housing stock assumptions based on ResStock Models

Type	Median Building Age	Median Sq. ft.
Existing Single-family	1960-1979	1690
Single-family New Construction	2000 - 2009	2176
Existing Multi-family	1960-1979	853
Multi-family New Construction	2000 - 2009	853

Regional assumptions on heating and cooling loads

The Project Team analyzed the scenarios in two representative regions of Wisconsin to cover the full range of climate variation in the state. Table 7 shows the degree days and design loads for both heating and cooling in Ashland and Milwaukee. The variation in heating and cooling load is relatively small in terms of system sizing but does have consequences for the dual fuel scenarios where the heat pump is primarily sized for cooling. Ashland is one of the northernmost cities in Wisconsin, requiring the most heating, while Milwaukee is situated at the southwestern corner of the state and requires less heating. Because the resulting usage and costs were similar, we applied a weighted average of these two climate zone results in the results tables in the next section.

Table 7: Regional assumptions on heating and cooling loads

[7] We started with the average statewide bundled natural gas rate (fixed and volumetric charges) from EIA and subtracted out a population-weighted average fixed charge associated with each therm based on rate information from the 5 Wisconsin dual-fuel utilities with largest customer counts.

	Location	Cooling Degree Days	Heating Degree Days	Source
Outdoor air temperatures	Milwaukee	529	7,284	TMY for MKE Airport
	Ashland	308	8,544	TMY for Ashland
Case	**Location**	**Design Cooling Load (BTU/h)***	**Design Heating Load (BTU/h)***	**Source**
Existing single-family	Milwaukee	22,704	27,707	2021 ASHRAE Sizing
	Ashland	14,009	29,935	2021 ASHRAE Sizing
New construction single-family	Milwaukee	20,963	23,656	2021 ASHRAE Sizing
	Ashland	12,037	25,555	2021 ASHRAE Sizing
Existing multi-family	Milwaukee	11,329	12,015	2021 ASHRAE Sizing
	Ashland	6,928	12,942	2021 ASHRAE Sizing
New construction multi-family	Milwaukee	7,344	8,103	2021 ASHRAE Sizing
	Ashland	5,608	8,727	2021 ASHRAE Sizing

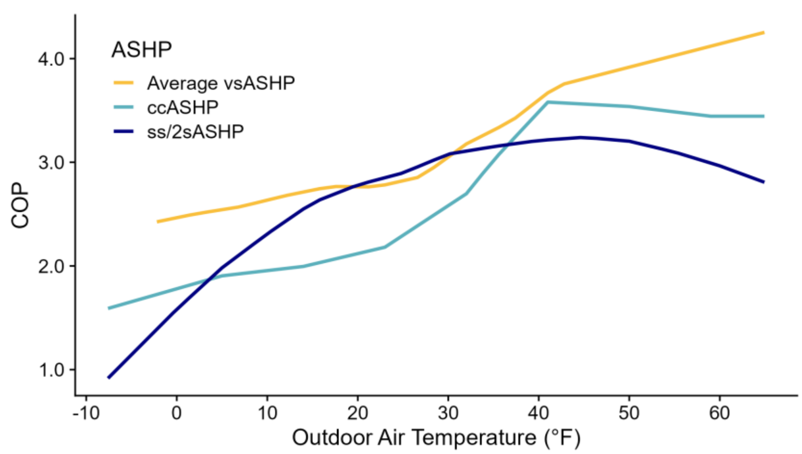
* Design loads calculated using 2021 ASHRAE handbook guidance, with a 99.6% heating design temperature and 0.4% cooling design temperature for each location

ASHP heating performance assumptions

Performance assumptions for ASHPs were based on three different equipment archetypes shown in Figure 4: a single or two-stage basic heat pump, an average variable-speed heat pump, and a cold-climate heat pump.[8]

Efficiency is defined by the coefficient of performance (COP), which represents how much output heat energy is provided for a comparable unit of input electric energy. Efficiency at different outdoor air temperatures was based on data available from manufacturers and the Project Team de-rated performance by 10% to account for field performance being lower than rated performance. Note that efficiency may be higher or lower depending on specific equipment installed and the quality of the installation. For example, in a study in Grand Rapids, Michigan, which has just slightly less heating degree days than Milwaukee, two single-stage ASHPs achieved estimated seasonal heating COPs of 3.9 and 3.4 with switchover temperatures of 20°F and 25°F respectively.[9]

Figure 4: ASHP heating performance assumptions



[8] ASHP types are defined in the Glossary
[9] https://slipstreaminc.org/sites/default/files/2022-05/dual-fuel-air-source-heat-pump-pilot.pdf

Estimated installed cost methodology

Based on common methods for HVAC contractor pricing, the Project Team applied two different mark-up strategies to estimate installed cost for the baseline equipment and equipment for each ASHP opportunity. In both methods the available equipment pricing is reflecting an entry-level contractor without contract pricing for the equipment. Percentages for mark ups are meant to be estimated based on the high end of the market trends, so actual estimates may be lower than estimated. The lower markup methods used in the multi-family scenarios reflect lower pricing for light commercial applications and non-owner-occupied buildings.

Markup method 1: This time and materials method is a common method used by many contractors. A contractor would calculate all the materials and equipment needed for the installation in an average scenario, including the maximum lengths of refrigerant lines and flue piping, permitting, and labor.

- Time and materials
- 40% mark up of material for single-family, 25% mark up of material for multi-family
- Labor calculated at 5X average pay to employee

Markup method 2: This equipment cost multiplier method is one of the higher markup methods utilized by market-leading contractors with a focus on growing their business. This method is more likely to be used in markets with low penetration of a given technology, or with technologies that are early in their adoption cycle. The Project Team included it because it typically produces higher estimates that may be reflective of real quotes in areas of the state with underdeveloped heat pump markets.

- 4 times multiplier applied to the equipment only for the minimum price for single-family, 3 times multiplier for multi-family
- 15% markup applied to multiplier for the maximum price
- Leaves 15% to negotiate with the consumer
- For reporting results, we show the average between the 15% markup and no markup price, or a 7.5% markup applied to the multiplier

In reporting results, we average Markup 1 and Markup 2, but have included them in Appendix A. We expect to overestimate cost in areas of the state with developed heat pump markets, so the true economics will be more favorable in those areas.

ECONOMIC AND EMISSIONS RESULTS FOR EACH SCENARIO

Costs from modeled fuel consumption changes are compared to installation and equipment costs for each scenario below. Baseline emissions and emissions changes from installing a heat pump are also reported for each scenario. Detailed results tables are outlined in Appendix A and price sensitivity considerations are outlined in Appendix B.

Single-family dual fuel natural gas displacement (AC replacement)

A resident with a ducted natural gas furnace wishes to add or replace their central AC. They opt to add a ducted heat pump to partially offset their heating load, while also adding or replacing their AC.

For this scenario, we modeled three different types of heat pumps (single/two speed, variable speed, and cold-climate), along with several different installation scenarios. The equipment in these scenarios is shown in Table 8.

- We show results for AC replacement in our modeling, but the analysis is similar with the counterfactual of adding an AC. The difference between the two scenarios is an additional upfront cost (~$1,000), but this incremental cost to add air conditioning is born for both the heat pump upgrade and counterfactual, and therefore results in no difference in incremental cost.
- We show two different replacement scenarios. The unlabeled scenario is the typical situation for a customer, where they intend to replace their AC but replace their furnace as well 2/3 of the time.[10] Specifiers recommend that customers do this because a matched furnace and AC are designed to work together, which increases efficiency and reduces maintenance costs. Also, if a customer is utilizing financing it provides peace of mind to the customer that they are preventing any near-term replacements and financing both systems in a bundle. The "swap out" scenario occurs when a customer purchases a pre-matched (or retrofit-ready variable-speed[11]) unit for their existing furnace, and therefore does not need a furnace replacement. This situation is a subset of the first case, but has cost implications that merit breaking it out on its own.

Table 8. Installed and counterfactual equipment by heat pump scenario for single-family natural gas dual fuel (SF NG DF) retrofits*

Heat pump installation scenario	Installed equipment	Counterfactual equipment
SF NG DF ss/2sASHP	Single/Two-stage ASHP (2 ton, 15 SEER, 9 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF NG DF vsASHP	Variable Speed ASHP (2 ton, 16.5 SEER, 9 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF NG DF ccASHP	Cold-Climate ASHP (2.5 ton, 17 SEER, 9.5 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF NG DF ss/2sASHP AC Swap out	Two-stage ASHP (2 ton, 15 SEER, 9 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)
SF NG DF vsASHP AC Swap out	Variable Speed ASHP (2 ton, 16.5 SEER, 9 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)
SF NG DF ccASHP AC Swap out	Cold-Climate ASHP (2.5 ton, 17 SEER, 9.5 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)

*Central AC and ss/2s ASHP sizes of 2-tons are for Milwaukee. Modeled sizes were 1.5 tons for Ashland.

[10] A Minnesota study on ASHP AC Replacements in Minnesota shows recent purchasers indicated that 63% of customers replaced their heating and cooling system at the same time and 37% replaced AC only. Those that replaced both were asked if that was their strong preference and they overwhelmingly responded yes. The contractor and distributor survey from this study also showed that contractors and distributors strongly push replacing both systems together for system benefits, ease of financing and it's an upsell for the contractor.

[11] Retrofit-ready variable-speed ASHPs are capable of retrofitting onto existing furnaces and hold a rating based on an outdoor unit and indoor unit match, rather than outdoor unit, indoor unit, and furnace match.

Available Rebates:
Focus on Energy and the Inflation Reduction Act provide for applicable rebates for air source heat pumps that can offset the cost of installation. For single-family home retrofits with an existing natural gas furnace, the following rebates apply:

- **Focus on Energy:**
  - $1000 for an air source heat pump
    - +$300 if it meets cold-climate specifications
  - $50-150 for an efficient furnace
- **HOMES:**
  - $2000 tax credit for a cold-climate air source heat pump
- **HEEHRA (2024+):**
  - Up to $8000 tax rebate for low to moderate income customers installing a cold-climate air source heat pump

Economic Results:
The results from comparative analysis of customer-facing lifetime costs, along with discounted payback time, are presented in Table 9.[12] As evidenced by the marginal operating cost difference, natural gas is an inexpensive heating fuel, so replacing a furnace with a high efficiency electric heat pump results in minimal cost savings derived primarily during the cooling season. Nonetheless, we find that in cases where a customer can upgrade to a pre-matched heat pump from a similar AC, rebates from Focus on Energy offset and even reverse the cost differential.

Table 9. Upfront and annual operating cost differences and payback for single-family natural gas dual fuel (SF NG DF) retrofits

Heat pump installation scenario	Estimated Upfront Cost	Upfront cost difference (incremental cost)	Annual operating cost difference	NPV payback w/o rebates (years)	NPV payback with rebates[13] (years)
SF NG DF ss/2sASHP	$12,558	$1,591	$119	20	5
SF NG DF vsASHP	$20,243	$9,276	$170	Never	Never
SF NG DF ccASHP	$27,728	$16,761	$156	Never	Never
SF NG DF ss/2sASHP AC Swap out	$8,795	$349	$119	4	<1
SF NG DF vsASHP AC Swap out	$16,128	$7,748	$170	Never	Never
SF NG DF ccASHP AC Swap out	$23,612	$15,167	$156	Never	Never

[12] We applied a 4% discount rate to arrive at net present value (NPV).
[13] Rebates applied include Focus on Energy rebates for all heat pumps as well as the tax credit and moderate income ($4,000) HEEHRA rebate for the cold-climate heat pump.

The heat pump efficiency declines with outdoor temperature, and Table 10 shows the bill parity temperature, the switchover point that results in equivalent annual bills to the pre-installation period. Although it is still slightly cheaper to run the natural gas furnace and the economic switchover temperature is typically higher for the modeled heat pumps[14], we set the switchover temperature to 40°F to extend the furnace lifetime and deliver emissions benefits. Paired with a high efficiency natural gas furnace, the heat pump will typically increase heating costs given the relative rates in Wisconsin. Operating above the bill parity temperature results in a heating bill increase that is outweighed on a yearly basis by the reduction in cooling costs in the summer.

Note that the cold-climate heat pump saves less energy and has a higher bill parity temperature than the modeled variable speed system that is not certified as cold-climate. This would not be the case if the system had electric resistance backup heat. The high bill parity temperature due to inexpensive natural gas means that the relevant operating temperatures are above 20°F, where the standard variable speed system operates more efficiently than the cold-climate system. However, a customer that moves to a dual fuel system as a stepping stone to full electrification should opt for a cold-climate heat pump as it can meet heating needs below 0°F.

Table 10. Modeled system size, average COP during operation, and bill parity temperatures for single-family natural gas dual fuel retrofits

Heat pump installation scenario	Size	Load-Weighted COP	Bill Parity Temp (°F)
SF NG DF 2sASHP	2 tons*	3.14	28
SF NG DF vsASHP	2 tons	3.30	19
SF NG DF ccASHP	2.5 tons	3.01	27

*2 tons modeled size reported is for Milwaukee, 1.5 tons for Ashland

Emissions Results:

Dual fuel operation of heat pumps in concert with natural gas drastically cuts emissions compared to solely natural gas operation. Operating the heat pump at high COP in warmer weather and the gas furnace during cold weather when the COP would be reduced optimizes on both cost and emissions, resulting in reductions over 20% from the baseline. These reductions are shown in Table 11. Further savings can be achieved by reducing the switchover temperature of the system below 40°F, but would increase heating costs and even raise bills above prior values if reduced to below the bill parity temperature. Note that our emissions models are levelized – true yearly reductions are weighted towards later years as renewables make up a larger proportion of the fuel mix.

These models were only run for the furnace replacement case. Although heat pump operation is the driver of emissions reductions, the gains from replacing the furnace would not be included in a swap out scenario and therefore reductions would be lower. However, swap outs are more likely to occur with preexisting furnaces that are newer and more efficient, so final emissions would be similar even if reductions are lower.

[14] Economic switchover based on 2022 fuel costs for natural gas dual fuel ASHP is the temperature at which the ASHP has coefficient of performance (COP) of approximately 3.75. In our performance assumptions, only the average variable speed heat pump achieves this high of a COP at approximately 35-40°F but as noted, ASHP performance may be higher or lower than assumed.

Table 11. Base carbon emissions, reductions under two grid scenarios, and percent reductions for single-family natural gas dual fuel retrofit (SF NG DF)

Heat pump installation scenario	Yearly Base Emissions from Heating (tons CO2)	BAU Emissions Reduction (tons CO2)	High Decarb Emissions Reduction (tons CO2)	Average % Emissions Reduction
SF NG DF 2sASHP	5.10	1.04	1.10	21%
SF NG DF vsASHP	5.10	1.15	1.19	23%
SF NG DF ccASHP	5.10	1.12	1.16	22%

Single-family dual fuel propane displacement (AC replacement)

A resident with a ducted propane furnace wishes to add or replace their central AC. They opt to add a ducted heat pump to partially offset their heating load, while also adding or replacing their AC.

The propane partial displacement scenario mirrors the natural gas scenario above, with a minor difference: given that propane is significantly more expensive to heat with than natural gas, the variable speed unit was sized up by one ton to cover more of the heating load. This was done under the expectation that the economic switchover would be lower and the heat pump would need sufficient capacity at those lower temperatures, which bore out in subsequent modeling.

Table 12. Installed and counterfactual equipment by heat pump scenario for single-family propane dual fuel (SF Propane DF) retrofits*

Heat pump installation scenario	Installed Equipment	Counterfactual Equipment
SF Propane DF ss/2sASHP	Single/Two-stage ASHP (2 ton, 15 SEER, 9 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF Propane DF vsASHP	Variable Speed ASHP (3 ton, 16.5 SEER, 9 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF Propane DF ccASHP	Cold-climate ASHP (2.5 ton, 17 SEER, 9.5 HSPF) Replace Furnace (3 ton, 95% AFUE)	Replace Air Conditioner (2 ton, 14 SEER) Replace Furnace 2/3 of time (3 ton, 84% AFUE)
SF Propane DF ss/2sASHP AC Swap out	Two-stage ASHP (2 ton, 15 SEER, 9 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)
SF Propane DF vsASHP AC Swap out	Variable Speed ASHP (3 ton, 16.5 SEER, 9 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)
SF Propane DF ccASHP AC Swap out	Cold-climate ASHP (2.5 ton, 17 SEER, 9.5 HSPF)	Replace Air Conditioner (2 ton, 14 SEER)

*Central AC and ss/2s ASHP sizes of 2-tons are for Milwaukee. Modeled sizes were 1.5 tons for Ashland.

Available Rebates:
Focus on Energy and the Inflation Reduction Act provide for applicable rebates for air source heat pumps that can offset the cost of installation. For single-family home retrofits with an existing propane furnace, the following rebates apply:

- **Focus on Energy:**
  - $400 for an air source heat pump displacing propane
    - +$100 if it meets cold-climate specifications
  - $50-150 for an efficient furnace
- **HOMES:**
  - $2000 tax credit for a cold-climate air source heat pump
- **HEEHRA (2024+):**
  - Up to $8000 tax rebate for low to moderate income customers installing a cold-climate air source heat pump

Economic Results:
The results from comparative analysis of customer-facing lifetime costs, along with discounted payback time, are presented in Table 13. Propane fuel is more than twice as expensive as natural gas, so installation of a heat pump saves much more. Instead of a marginal difference, customers can expect to save nearly $75-$100 per month. This difference makes all rebated scenarios cost-effective within the lifetime of the heat pump, although the cold-climate unit is not cost-effective without rebates.

Table 13. Upfront and operating cost differences and payback for single-family propane dual fuel retrofits (SF Propane DF)

Heat pump installation scenario	Estimated Upfront Cost	Upfront cost difference (incremental cost)	Operating cost difference	NPV payback w/o rebates (years)	NPV payback with rebates (years)[15]
SF Propane DF ss/2sASHP	$12,558	$1,591	$872	2	2
SF Propane DF vsASHP	$20,309	$9,342	$1,299	9	9
SF Propane DF ccASHP	$27,728	$16,761	$1,155	23	12
SF Propane DF ss/2sASHP AC Swap out	$8,795	$349	$872	<1	<1
SF Propane DF vsASHP AC Swap out	$16,193	$7,748	$1,299	7	7
SF Propane DF ccASHP AC Swap out	$23,612	$15,167	$1,155	19	10

[15] As with natural gas, rebates applied include Focus on Energy rebates for all heat pumps as well as the tax credit and moderate income ($4,000) HEEHRA rebate for the cold-climate heat pump

By design, all heat pumps are capacity-limited when temperature drops to a point where the heat load beyond the capacity of the system. The dual speed heat pump is sized for cooling and only able to operate down to 28°F. The variable speed heat pump, however, operates down to 7°F and the cold-climate heat pump meets heating demand down to -4°F. In the cold-climate case, the propane furnace is truly providing emergency backup heat, and would rarely turn on in a year. Because the single speed and variable speed units cut off before the lowest temperatures, their load-weighted COP is higher than the cold-climate unit.

Table 14. Modeled system size, average COP during operation, and capacity limit temperatures for single-family propane dual fuel (SF Propane DF) retrofits

Heat Pump Installation Scenario	Size	Load-Weighted COP	Capacity Limit Temp (°F)
SF Propane DF ss/2sASHP	2 tons	3.14	28
SF Propane DF vsASHP	3 tons	3.25	7
SF Propane DF ccASHP	2.5 tons	2.76	-4

*2 tons modeled size reported is for Milwaukee, 1.5 tons for Ashland

Emissions Results:

In addition to being much more expensive than natural gas, propane emits slightly more carbon when burned. Switching to a heat pump results in larger absolute reductions in carbon emissions than in the natural gas cases. These reductions are shown in Table 15. The percentage reduction for a single/two speed unit is fairly close because about the same amount of propane is displaced for a similar economic switchover. When the switchover point is decreased for the variable speed and cold-climate units, more propane is displaced and therefore the percentage emissions reductions are higher. At the lowest temperatures, however, the reduced COP of the heat pump results in more lifetime emissions from less efficient use of a fossil fuel-powered grid, hence the lower percentage reduction for the cold-climate unit. As with natural gas, emissions come from the furnace replacement scenario.

Table 15. Base carbon emissions, reductions under two grid scenarios, and percent reductions for single-family propane dual fuel (SF Propane DF) retrofits

Heat pump installation scenario	Yearly Base Emissions from Heating (tons CO2)	BAU Emissions Reduction (tons CO2)	High Decarb Emissions Reduction (tons CO2)	Average % Emissions Reduction
SF Propane DF ss/2sASHP	6.11	2.19	2.39	37%
SF Propane DF vsASHP	6.11	3.10	3.45	54%
SF Propane DF ccASHP	6.11	2.64	3.11	47%

Single-family all-electric new construction

In a single-family home original design, it was going to be constructed with a ducted natural gas furnace and central AC. Instead, it is designed to be heated and cooled with a ductless mini-split and electric baseboard backup.

When constructing a single-family home, there are substantial cost savings from the flexibility of heat pumps. In this scenario, the baseline is a home constructed with a ducted gas furnace and central air conditioner. The counterfactual a ductless mini-split and electric baseboard backup, and can be heated and cooled without ducts under the assumption of an open floor plan. Unlike the dual fuel scenario, this home requires no gas service and additional cost savings are assumed from eschewing the service pipe hookup costs. By contrast, homes built today have the appropriate panel sizing (200A) already and require no electrical upgrades for the heat pump. The specifications of the assumed equipment are shown in Table 16.

Table 16. Installed and counterfactual equipment for single-family all-electric new construction (SF All-Electric NC)

Heat pump installation scenario	Installed Equipment	Counterfactual
SF All-Electric NC	Ductless Mini-Split HP (2 ton, 23 SEER, 12.5 HSPF) 5x ER Baseboard (1kW each)	Central Air Conditioner (2 ton, 14 SEER) Gas Furnace (3.5 ton, 95% AFUE)

Available Rebates:

Focus on Energy has rebates for new construction, but these do not explicitly apply to heat pumps. Similarly, the Energy Efficient Home Credit through the IRA provides credits for new homes meeting ENERGY STAR standards, and higher rebates for Zero Energy Ready Homes, but neither of these credits are directly contingent on a heat pump. A home can meet the standard without a heat pump, and a home with a heat pump could fail to meet the standard. Given that lack of direct applicability, we did not consider rebates for single-family new construction.

Economic Results:

The results from comparative analysis of customer-facing lifetime costs are presented in Table 17. Unlike the other scenarios, the Project Team found that upfront costs would be lower to install a heat pump. However, operating costs are higher than the gas furnace baseline for an all-electric home due to reduced COP and to switchover to electric backup at the lowest temperatures. The operating cost difference is mitigated by the removal of $155 in gas fixed fees per year, representing the average from the 5 largest gas utilities in Wisconsin. Taken together, the savings from building an all-electric home without ducts or gas service are never outweighed by the moderately increased operating costs.

Table 17. Upfront and operating cost differences for single-family all-electric new construction (SF All-Electric NC)

Heat pump installation scenario	Estimated Upfront Cost	Upfront cost difference (incremental cost)	Operating cost difference*
SF All-Electric NC	$14,083	-$9,367	-$341.52

* Operating cost difference includes the absence of a gas service fee

Emissions Results:
Opting for heat pumps in newly constructed single-family homes reduces emissions by 9-23% compared to the baseline home with a natural gas furnace and AC, Table 18. This reduction is lower than the dual fuel scenario because operation during the coldest weather, as well as electric backup, consumes electric energy less efficiently. Especially in the near term, the grid is partially composed of fossil fuel generation and generates more emissions than a gas furnace during low temperature operation.

Table 18. Base carbon emissions, reductions under two grid scenarios, and percent reductions for single-family all-electric new construction (SF All-Electric NC)

Heat pump installation scenario	Yearly Base Emissions from Heating (tons CO2)	BAU Emissions Reduction (tons CO2)	High Decarb Emissions Reduction (tons CO2)	Average % Emissions Reduction
SF All-Electric NC	3.93	0.36	0.89	16%

Multi-family all-electric new construction
A new multi-family building was originally going to be constructed with central gas boiler heating and window unit AC. Instead, it is designed to be heated and cooled with ductless mini-splits.

The multi-family new construction scenario assumes that the new building can be built sufficiently tight to remove the need for backup heat. As with single-family, we take into account the absence of the (hydronic) heat distribution system and the gas hookup. The cost of wiring upgrades to support all-electric operation is factored in. The counterfactual is a central boiler whose costs are divided among the assumed 8 units of the building. The specifications of the assumed equipment for each unit are shown in Table 19.

Table 19. Installed and counterfactual equipment for multi-family all-electric new construction (MF All-Electric NC)

Heat pump installation scenario	Installed Equipment	Counterfactual
MF All-Electric NC	Ductless Heat Pump (1 ton, 23 SEER, 12.5 HSPF)	Gas Boiler (150 kBTU, 96% AFUE, serving 8 units) Window AC (1 ton, 10 SEER)

Available Rebates:
As with the single-family new construction case, there are rebates for energy efficient and zero energy buildings, but heat pumps are not directly rebated.

Economic Results:
The results from comparative analysis of customer-facing lifetime costs, along with discounted payback time, are presented in Table 20. The gas service fee savings and cooling savings drive costs down, but due to the cost efficiency of having a centralized boiler and the fact that natural gas is an inexpensive fuel for heating, the operating cost difference is marginal for a new multi-family building. However, if

the building does receive a rebate through Energy Efficient Home Credit, it could reduce the upfront cost difference dramatically.

Table 20. Upfront and operating cost differences and payback for multi-family all-electric new construction (MF All-Electric NC)

Heat pump installation scenario	Estimated Upfront Cost	Upfront cost difference (incremental cost)	Operating cost difference*	NPV payback (years)
MF All-Electric NC	$8,351	$4,287	$17.72	Never

* Operating cost difference includes the absence of a gas service fee

Table 21 shows the load-weighted COP for the system. Because this system has no backup, this is the COP when covering 100% of the load for the unit.

Table 21. Modeled system size and average COP during operation for multi-family all-electric new construction (MF All-Electric NC)

Heat pump installation scenario	Size	Load-Weighted COP
MF All-Electric NC	1.2 tons	2.11

Emissions Results

Multi-family units are smaller than single-family residences and connected to a larger building, so they have substantially lower heating loads. Given the reduced COP from operating down to low temperature, all electric new construction reduced emissions by only 4-18% compared to a gas baseline. As mentioned in prior sections, these emissions are also weighted towards later in the unit's life cycle, as a greater portion of the fuel mix becomes carbon free.

Table 22. Base carbon emissions, reductions under two grid scenarios, and percent reductions for multi-family all-electric new construction (MF All-Electric NC)

Heat pump installation scenario	Yearly Base Emissions from Heating (tons CO2)	BAU Emissions Reduction (tons CO2)	High Decarb Emissions Reduction (tons CO2)	Average % Emissions Reduction
MF All-Electric NC	1.01	0.04	0.18	11%

Multi-family electric resistance heat

An owner of a multi-family building with electric resistance heat would like to add cooling. The owner opts to add a ductless heat pump to partially offset the heating load while also providing cooling to tenants.

This scenario differs from the others in that the multi-family building already has electric heat, albeit inefficient baseboard resistance heat. Unlike the new construction scenario, the building is assumed to be less well-sealed and insulated, and therefore a larger ductless heat pump is required for each unit. We assumed a window air conditioner as the baseline, which is conservative compared to a more expensive packaged terminal air conditioner (PTAC) unit. No electrical upgrades are required, and it is assumed that if the building has gas service for water heating it will remain.

Table 23. Installed and counterfactual equipment for multi-family electric resistance retrofit

Heat pump installation scenario	Installed Equipment	Counterfactual
MF DHP Retrofit	Ductless Heat Pump (1.5 tons, 23 SEER, 12.5 HSPF)	Baseboard electric heat (5 kW) Window AC (1 ton, 10 SEER)

Available Rebates:
Focus on Energy and the Inflation Reduction Act provide for applicable rebates for air source heat pumps that can offset the cost of installation. For multi-family retrofits with existing baseboard heat, the rebates are the same as for single-family retrofits:

- **Focus on Energy:**
    - $1000 for an air source heat pump
        - +$300 if it meets cold-climate specifications
    - $50-150 for an efficient furnace
- **HOMES:**
    - $2000 tax credit for a cold-climate air source heat pump
- **HEEHRA (2024+):**
    - Up to $8000 tax rebate for low to moderate income customers installing a cold-climate air source heat pump

Economic Results:
The results from comparative analysis of customer-facing lifetime costs, along with discounted payback time, are presented in Table 24. Note that the only cost assumed in the baseline is the cost of a window AC with handyman assistance, so the "NPV payback without rebates" case is conservative. The ductless heat pump will meet cold-climate specifications and customers are likely to meet the moderate-income threshold from HEEHRA. They would be eligible for rebates or credits from $3,300 to $9,300, more than the incremental cost of installation. For that reason, the payback time for customers is very short after applying maximum rebates.

Table 24. Upfront and operating cost differences for multi-family electric resistance retrofit (MF DHP Retrofit)

Heat pump installation scenario	Estimated Upfront Cost	Upfront cost difference (incremental cost)	Operating cost difference*	NPV payback w/o rebates (years)	NPV payback with rebates (years)
MF DHP Retrofit	$9,782	$8,993	$579.81	25	1

The system has a similar load-weighted COP to the ductless unit in the New Construction case, evidencing that displacing electric resistance heat is vastly more cost-effective than displacing natural gas. Electric resistance heat does not come on until -6^{o}F and only runs for 3 hours total in our model, so the heat pump runs throughout most of the winter in Wisconsin. Table Y shows the load-weighted COP and capacity switchover temperature.

Table 25. Modeled system size, average COP during operation, and capacity limit temperatures for multi-family electric resistance retrofit (MF DHP Retrofit)

Heat pump installation scenario	Size	Load-Weighted COP	Capacity Limit Temp (°F)
MF DHP Retrofit	1.5 tons	2.2	-6

Emissions Results:
Retrofitting a ductless heat pump to a unit with electric baseboard heat reduces relative carbon emissions as much as the dual fuel propane scenarios. Residents can reduce their footprint by roughly 50%, Table 26. In this case, note that carbon emissions will be weighted early as opposed to late and that there will be more savings in the BAU case than in the High Decarbonization case. This is because the ductless unit is reducing total electricity consumption instead of increasing it, and therefore saves more emissions when the electric fuel mix has more fossil fuels.

Table 26. Base carbon emissions, reductions under two grid scenarios, and percent reductions for multi-family electric resistance retrofit (MF DHP Retrofit)

Heat pump installation scenario	Yearly Base Emissions from Heating (tons CO2)	BAU Emissions Reduction (tons CO2)	High Decarb Emissions Reduction (tons CO2)	Average % Emissions Reduction
MF DHP Retrofit	2.90	1.55	1.30	49%

VALUE PROPOSITION TAKEAWAYS

While individual residences and projects should be assessed on a case-by-case basis, this scenario analysis points to a few major takeaways.

- Currently available air source heat pumps, from single speed to cold-climate units, are an excellent choice to displace existing propane and electric resistance heating. Modeling shows large cost and emissions savings in these scenarios, with short payback times. As these savings increase based on the amount of heating load displaced, program administrators and customers have flexibility in selecting a heat pump.

- The bulk of all-electric new construction cost savings comes from avoiding distribution systems and gas hookup fees, and operating costs are moderately higher or similar to natural gas costs. Depending on the building location and design needs, the avoided upfront costs can vary widely. The median single-family home should see lifetime cost savings despite higher operating costs, while the median multi-family building will be more expensive upfront with marginal operating cost differences. Emissions benefits compared to new efficient natural gas construction are smaller than other scenarios. Targeting Energy Star standards or a Zero Net Energy certification will provide rebates that boost the economics, as will focusing on areas without current natural gas service.

- In Wisconsin, natural gas remains an inexpensive heating fuel compared to most of the models and operating ranges of air source heat pump. Requiring new air conditioners to also serve as a heat pump delivers emissions savings, results in low marginal costs, and offers flexibility for customers to deepen emissions savings by running the heat pump at lower temperatures. Variable speed and cold-climate units are early in their lifecycle and may become more economically attractive as their upfront cost drops or if natural gas prices rise.

MARKET TRANSFORMATION ROADMAP

The Market Transformation Roadmap represents the product of the needs assessment and building stock and top ASHP opportunities analyses. This process entailed distilling and organizing project insights and discerning how they inform high impact actions for Wisconsin stakeholders to help transform the Wisconsin HVAC market. The Project Team utilized Mural, an interactive planning application, to distill the project analysis and needs assessment findings for this purpose. Appendix C contains the Mural "board" we created to finalize the roadmap.

The Project Team created the Market Transformation Roadmap by working backward from the destination we seek to arrive at: transforming the Wisconsin HVAC and heat pump market with an achievable but challenging goal. Our goal is that air source heat pumps are the first choice for both customers and contractors for heating and cooling by 2030. This goal aligns with that of the Midwest region and the federally funded Midwest Air Source Heat Pump Collaborative.

With our end goal defined, we articulated the impacts that would need to be achieved between now and our goal year, 2030, to enable us to envision what this goal would look like in actuality in the market. These impacts include the following:

- Increased awareness of ASHPs and their value proposition by customers and contractors
- More contractors installing ASHPs in the state of Wisconsin
- Increased customer demand for ASHPs over time
- Customers having an easier time engaging qualified installers and soliciting competitive bids from them
- Improvements to the economic value proposition as we near 2030.

When we see these impacts in the Wisconsin HVAC market over the coming three to five years, we will know we are making headway toward our 2030 goal.

From the needs assessment, we were able to discern both the barriers and opportunities of ASHP adoption in the Wisconsin residential HVAC market. The primary barriers we identified, which are inhibiting the growth of ASHPs in the market today include the following:

- An undefined and weak value proposition for customers, landlords, contractors, distributors, and manufacturers
- High first cost for both the product and installation
- High operating costs in comparison to alternate fuels that are currently more inexpensive in the region
- Lack of installer technical proficiency and knowledge of best practices and maintenance for ASHPs

- Contractor labor shortage to meet both current and future demand
- Lack of contractor customer awareness, experience, and trust between the two parties.

Opportunities, or leverage points within the current market for rapidly increasing growth effectively and efficiently, were identified as the following:

- Increasing motivation to add cooling to homes
- Increasing motivation to reduce carbon emissions from customers, manufacturers, utilities, media, federal, state, and municipal actors
- State and Federal initiatives and incentives
- Cost saving and resilience benefits allowing for fuel flexibility in dual fuel applications would empower both customers and the utilities that serve them.

Based on our vision for the Wisconsin HVAC market in 2030, we know that actions taken over the next three to five years need to be designed to either overcome these critical barriers or leverage existing opportunities for accelerated growth.

PLAYBOOK RECOMMENDED ACTIONS

Upon defining the market transformation roadmap destination, desired impacts, and barriers/opportunities we developed the following recommended actions as the “playbook” for different stakeholders to accelerate the technology and help achieve a future where ASHPs are the first choice by contractors and customers by 2030.

State of Wisconsin

We recommend Wisconsin state and regulatory officials consider the following actions to drive market transformation toward ASHPs.

Amplify utilities and Focus on Energy
Based on a Commission decision in April 2023, Focus on Energy will administer the High-Efficiency Electric Home Rebate Act (HEEHRA) and Home Energy Performance-Based, Whole-House Rebates (HOMES) programs. It is imperative that the design is complementary to current Focus on Energy offerings. Further, investing in program elements that support Quality Installation (QI) are critical in this phase of the market where contractor knowledge and experience are low and the potential for installations to underperform in terms of energy savings actualized. Supporting quality installations will help the market grow in a sustained fashion, mitigate negative customer experiences, and ensure installations achieve desired energy savings and carbon reductions.

Motivating utilities and regulators to design and adopt rates that increase the value proposition for heat pumps will compensate for the increased costs homeowners switching from low-priced natural gas to a heat pump are likely to experience. The Midwest ASHP Collaborative published a white paper in June that advocates for and justifies a lower electric rate for all-electric and dual fuel ASHP applications. This innovative rate design appropriately accounts for the fixed and variable cost calculations that ultimately makes up electric rates, ensuring customers who adopt ASHP technology are not overpaying and that customers who have yet to adopt ASHPs are not unfairly making up the cost differential of those who have done so. The Collaborative's white paper offers guidance for Wisconsin utilities and regulators to design and justify these rates for residential customers and should be utilized as a resource to do so.

Current metering structures placed on multi-family units can be a direct barrier to multi-family ASHP applications. For example, flexibility to meter heat pumps through a common meter structure, rather than on the resident meter, would facilitate adoption of heat pumps and solar to offset the electric load from the heat pumps. Regulatory bodies must support metering strategies to increase heat pump adoption in multi-family properties and reduce energy burden for residents. Based on the current experience of project partners, it is understood that state and regulatory commission staff will need to act to remove or relax these regulatory and financial hurdles associated with the current metering structure requirements to accelerate adoption of ASHPs in the multi-family space, ensuring equity in adoption throughout the state.

Finally, the Commission has indicated it finds it reasonable for Focus on Energy to build off Quad IV determinations and support research to determine value of demand response for ASHPs, including assessing strategies for achieving greater demand savings and better understanding the additional value of demand savings.

Support market growth

The State can and should play a lead role in facilitating workforce development initiatives that equitable grow the pool of installers needed to achieve the scale of technology adoption necessary to transform the market in Wisconsin. The State can partner and support community-based organizations that are well-suited to recruit and train new workforce while also removing barriers to attract a diverse workforce. For additional support, we recommend that the State become actively involved with the Midwest ASHP Collaborative, which is actively engaging with states and utilities around this topic.

Creating a structure for market transformation programs in the state will go beyond the current resource acquisition framework Focus on Energy currently employs to capture energy savings to fully address the systemic market barriers outlined in this report. The Wisconsin Public Service Commission has an opportunity to fund a statewide market transformation initiative in the next quadrennial, which would provide the structure and funding to adequately address the barriers presented in the market transformation roadmap and help achieve ASHP benefits to the fullest. Minnesota and Illinois both have structures enabling statewide market transformation programs that can be referenced to develop a WI based program. Additionally, Cadmus' market transformation potential study on behalf of Focus on Energy will help support this effort. Engaging with neighboring state and utility initiatives and regional and national working groups to stay on top of the cutting-edge trends and participate in cross-pollination of ideas will be helpful. A few examples include the National Heat Pump Field Validation Partnership, Midwest ASHP Collaborative, Minnesota Efficient Technology Accelerator, ComEd's Emerging Technologies Program, the Minnesota ASHP Collaborative, and Michigan Heat Pump Collaborative.

The State must consider weatherization alongside ASHP contractor training and workforce development to realize the benefits of weatherizing buildings alongside installing ASHPs in cold-climates. By ensuring that they are promoted together when it comes to customer communication, workforce development, and training, the State has an opportunity to align efforts across these different program channels to streamline learnings and realize the benefits of decreasing heating and cooling loads while electrifying both.

Finally, the State must work to integrate ASHP training in workforce and education plans of state agencies and state-funded higher education institutions. This can include Department of Workforce Development, Department of Public Instruction, and state-funded higher education institutions like technical colleges. Training contained in programs and coordination among those programs is helpful, but a legitimate workforce strategy stemmed in the agencies that focus on workforce development overall is likely to go farther to building and retaining the workforce needed to meet our ASHP adoption goals.

Focus on Energy

We recommend the Focus on Energy program take the following actions to drive accelerated adoption of ASHPs.

Play a leading role in customer education and guidance
Focus on Energy can play a leading role in customer education by utilizing its ASHP Customer Buying and Operational Guide.[16] In addition, Focus on Energy can collaborate with and engage with cities, manufacturers, utilities, and the state to raise awareness around the technology with consumer awareness campaigns.

Support contractor education and how to connect with customers
Focus on Energy can support contractor education and lead generation by increasing contractor product experience and training, in collaboration with distributors and manufacturers, and draw on available resources available both regionally and nationally. When engaging with contractors, Focus should provide data-driven information and case studies on ASHP applications. Those designated in this playbook as having the highest value propositions will be most helpful to contractors.

Finally, Focus is well positioned to build a network of heat pump contractor champions to connect qualified contractors with interested customers. Focus on Energy can look toward the Minnesota ASHP Collaborative and the Michigan Heat Pump Collaborative as neighboring state examples of a “preferred contractor network” and “contractor designation” that tackles the topic at a statewide level. There is a cross-cutting opportunity for contract development and building market momentum in the need to connect interested customers with qualified contractors.

To support development of a heat pump contractor champion network, utilities and communities can be source of consumer marketing, education, and awareness building to generate consumer leads and drive them to network of contractors that serve their areas. Additionally, manufacturers and distributors can support such an effort by being part of the design process for contractors and by delivering any required trainings. Manufacturers are well-placed to help develop territory managers that support this designation, while distributors can help contractors with design, sizing, and equipment selection to effectively participate in network. The Wisconsin Heat Pump Coalition is a valuable network that gets manufacturers and distributors on same page and can assist in setting up a program.

Address nuanced multi-family and low-income applications
Multi-family applications offer a major opportunity to serve low-income customers. Electric resistance heating, which offers the best economic opportunity for heat pumps, is concentrated in lower-income

[16] This guide is in final stages of development and planned for publication in 2023.

housing, as documented in a recent report by CEE and Elevate.[17] Our housing stock analysis also found that electric resistance heating is evenly widespread throughout Wisconsin. Focus on Energy could develop programs that targets replacing electric resistance heat in multi-family housing with heat pumps, including increased incentives for low-income multi-family.

Multi-family applications face unique challenges as compared to single-family, such as the split-incentive problem, and typically involve larger buildings with more complex existing heating systems and metering structures that can make heat pump retrofits more challenging to implement. Focus on Energy can encourage heat pump adoptions in this sector through supporting heat pump pilot programs in multi-family buildings that demonstrate the technology. Pilot program should result in case studies that showcase positive outcomes (e.g., improved resident satisfaction, improved comfort and air quality, reduced utility bills), document lessons learned for future projects, and be tailored to the concerns of multi-family building owners. In addition, Focus could lead emerging technology research in this sector; for example, Focus could explore the viability of window ASHPs or other emerging technologies that will serve multi-family customers. Finally, Focus could also explore various program design opportunities that are tailored toward low-income multi-family building owners.

Synergize with state administration of Inflation Reduction Act rebate programs
Focus on Energy is well positioned as a statewide energy efficiency program to ensure synergy with administration of the Inflation Reduction Act programs in Wisconsin. Special attention to synergizing customer messaging, experience, and quality assurance of participating trade allies will be paramount.

Play a supportive role and partner with others on workforce development
While Focus on Energy is not positioned to lead on workforce development, Focus can help support efforts in the state and community and collaborate with other stakeholders, serving as a bridge between communities and the State on this topic.

Utilities

We recommend Wisconsin electric and dual-fuel utilities take the following actions to drive market transformation towards ASHPs.

Seize early opportunities
Utilities should seize early opportunities to drive technology momentum. Targeting and prioritizing the ASHP opportunities with a compelling economic value will help bring immediate value to customers and scale market development. These include targeting single-family and multi-family homes with propane heat, electric heat, and single-family new construction. Utilities can leverage advanced metering infrastructure (AMI) data to identify customers with high electric heating loads. Utilities can help facilitate stacking of federal and state incentives to maximize economic benefits and provide communications on benefits and opportunities to their customers.

Prepare for shifting electric demand
With growing electrification of home heating, Wisconsin electric utilities will face demand for electricity and an increase in demand during winter season. One utility interviewed communicated how they are starting to prepare for winter electricity demand peaks. Wisconsin electric utilities will benefit from

[17] https://s3.us-east-1.amazonaws.com/focusonenergy/staging/inline-files/2021/EERD_ASHP_Project-Final_Report.pdf

piloting projects to manage load and consider rate reforms to reflect the changing nature of demand and how that affects their distribution network. Dual fuel heat pumps should be considered as one possible solution to manage winter peaks and Wisconsin's electric utilities should consider how reforms to rates can reflect the changing nature of demand. Wisconsin utilities should consider adopting recommendations from the Midwest ASHP Collaborative whitepaper on electric rates for hybrid air source heat pumps.[18]

Drive workforce evolution

While driving workforce evolution is best led by the market, State and Focus on Energy, utilities can play a supportive role in helping drive development and growth of the ASHP contractor network serving their territory through both program incentives and education initiatives. This may include communication to trade ally lists and for rural electric cooperatives that are not a part of the Focus on Energy program to collaborate on trainings.

Actively engage

Utilities are often leaned on for customer service and will need to develop internal competency to effectively respond to a likely uptick in customer inquiries and share relevant resources and guides from others such as Focus on Energy. Wisconsin utilities will also benefit from being equipped to support customers with information relevant to the service territory and exchanging insights and best practices with utilities or utility-funded collaboratives working on ASHPs in neighboring states.

Local governments, communities and tribes

Local governments, community groups, and tribes are closest to members of their community and stand to play a key role in market transformation towards ASHPs. We recommend these actors take the following actions.

Act as a facilitator and convener

Local governments, community groups, and tribes are recommended to act as a facilitator and convener for contractors, consumers, and utilities to nudge the market. To engage contractors, they can partner with utilities, trade associations, manufacturers, and distributors to host events with a goal of growing the *local* heat pump contractor community. These events should connect contractors with heat pump resources (such as research and rebates) and highlight the importance of incorporating heat pumps into their business offerings.

To engage consumers, these groups can launch campaigns that increase consumer education and awareness around heat pumps, especially on top heat pump opportunities relevant to their community. Consumer education from larger state programs can be adapted to the local concerns and needs of the community (i.e., climate change, air quality, comfort, utility bills, etc.). Community-based initiatives can provide an effective platform for raising awareness of heat pumps. Resources distributed could include information from their local utility and data from this report that supports consumer value propositions.

[18] https://www.mncee.org/developing-electric-rates-hybrid-air-source-heat-pumps-midwest?utm_source=CEE+Newsletter&utm_campaign=d730abc1d1-CEENEWS_SUMMER2022_COPY_02&utm_medium=email&utm_term=0_c10a2417e9-d730abc1d1-516879905

Finally, we recommend engaging with Focus on Energy and their local utilities to stay up to date on heat pump resources, incentives, and research relevant to their consumers and contractors, so these resources can be shared during hosted events or educational campaigns.

Lead demonstration projects

The importance of local, relevant demonstration projects was frequently mentioned during the needs assessment interviews. Local governments, community groups, and tribes should lead the implementation of heat pump projects in public buildings to develop local case studies and opportunities for learning and education in case study spaces that demonstrate heat pump performance, successes, and lessons learned in their community. Initial demonstration projects should target low-hanging fruit opportunities, such as buildings with electric resistance heat (more certain utility savings), new construction (less complex), or added access to cooling (public need). These projects should report verified savings, as this is a key metric consumers and contractors are looking for to feel confident in heat pumps in their community. In addition, communities could work with builders on all-electric model homes in new developments where the home could serve as a source for education to homebuyers and realtors on the benefits of ASHPs.

Finally, communities looking to be a leader in heat pumps should consider adding heat pump targets to their climate goals and creating systems to track heat pump installations in their community over time.

Advocacy

Finally, local governments, community groups, and tribes should be an advocate for their constituents to utilities and regulators on their needs to enable heat pump adoption. For example, they could advocate for the adoption of utility rates that increase the value proposition for heat pumps. In addition, they could advocate for incentives that reduce upfront costs of heat pumps to increase the affordability and equitability of access to these systems.

Cross-cutting actions

While many of the recommended actions outlined above for each stakeholder will have maximum impact if they are working together, consumer awareness and developing the new workforce are two cross-cutting actions that would particularly benefit from coordination among the different stakeholders. The visuals below illustrate the role each of these actors is best positioned to play in furthering consumer awareness and growing the new workforce.

Consumer Awareness

State

Provide materials and support through the IRA rebate roll out. Leverage clear and consistent messaging.

Focus on Energy

Main touchpoint and source of dissemination for consumer awareness building : serves as trusted source for basic education and customer support, awareness campaigns, and resources.

Utilities

Amplify and reinforce messaging deployed through Focus on energy. Provide customer support and connect customers to available resources.

Communities

Community-based initiatives can be compelling platform to increase customer engagement and awareness. Leverage Focus on Energy messaging for consistency but adapt messaging to be locally relevant and resonate with community members.

Developing the New Workforce

State

Play leading role. Convene and guide where other stakeholders can support.

Focus on Energy

Not directly in purview but can support and connect dots, particularly though design and implementation of a heat pump contractor designation which can incorporate elements to develop the new workforce.

Utilities

Sponsor scholarships and education for energy efficiency jobs.

Communities

Utilize existing infrastructure to provide wraparound services and connect dots between recruitment, trade schools, and employers

PLAYBOOK DISSEMINATION AND SUPPORT STAKEHOLDER ACTION

A key aspect of this project was to disseminate the playbook and begin providing planning, technical and analytical support to primary stakeholders. Below is a summary of our team's dissemination and stakeholder supportive activities from initiation of project Summer 2022 to June 2023. Thus far, it appears that the playbook is driving momentum among actors to take action.

DISSEMINATION

State of Wisconsin and Focus on Energy:
Our team disseminated the playbook to State of Wisconsin and Focus on Energy staff first. This included Commission staff, Housing and Community Resources (DEHCR) staff involved in the low-income weatherization program, and Focus on Energy staff. We also met with State staff to gather feedback and identify points of interest for further engagement.

Public Webinar on the Playbook:
The primary method of playbook dissemination was a public webinar held in May 2023 that was made available to all stakeholders. Over 100 individuals registered, and 70 individuals attended the live 90-minute presentation. The webinar playbook slides as well as the extended playbook were published on the event landing page as well as a recording of the presentation and discussion. Appendix D displays results from attendee polling and the post-webinar survey.

Disseminating playbook to Tribes
Tribal partners must have access to technology and support to decarbonize Tribal housing stock and buildings. Propane and electric resistant heat are used throughout the Tribal building stock and switching to more efficient heat pumps present excellent opportunities for carbon and cost reduction. Outreach on clean energy and heat pumps to Tribal partners in Wisconsin was and is being completed via the Great Lakes Indian Housing Association (GLIHA). Elevate has established an energy advisory subcommittee within GLIHA. The energy advisory committee process allows for direct feedback from Tribal partners on efficiency and clean energy issues related to housing. Additionally, an outcome of the advisory committee was a training to GLIHA members in early 2023. The team plans to continue to disseminate information and this playbook through GLIHA, directly to Tribal housing authorities, and through other Tribal associations such as the Midwest Tribal Energy Resources Association (MTERA).

BEGIN SUPPORTING STAKEHOLDERS

To capture momentum in stakeholder interest in ASHP market transformation and provide further guidance building upon recommended actions in the playbook our team provided initial support to a variety of stakeholders who are taking action to help make ASHPs the first choice for heating and cooling by 2030. Below is a summary of some of the support our team provided.

Dane County Free Heat Pump Workshop for Contractors
Stemming from the Wisconsin Heat Pump Coalition, with the support from engaged manufacturers and distributors Dane County pioneered and organized a free heat pump workshop for HVAC contractors. Our Project Team supported the event by supporting event planning and providing and delivering content from the project related to ASHP market trends, economics, and the customer and contractor journey.

This project's destination of "ASHPs being the first choice for heating and cooling by 2030" was communicated by Dane County as this local government leader challenged contractors in Dane County to beat that timeline and start offering an ASHP on every bid moving forward. The event also included manufacturer and distributor panels, presentations on Focus on Energy, the Inflation Reduction Act, and discussion on how to move forward.

Over 75 HVAC contractors attended the event. From pre-event and post-event feedback Dane County identified that contractors significantly increased the portion of their proposals on which they plan to include a heat pump. Dane County is actively considering how to build upon the momentum of this event and this event served as a pilot model that other stakeholders in Wisconsin are considering replicating or adapting.

Residential: UW Madison Clean Energy Funding Series
In May, 2023 a representative of the Project Team presented on customer planning for ASHPs at an event hosted by the University of Wisconsin-Madison Extension as part of their clean energy funding webinar series. Over 125 individuals from across Wisconsin registered for the event and the presentation was recorded and published on the University of Wisconsin webpage. In this presentation, we drew from project findings and insights to provide Wisconsin residents guidance in planning for a switch to an ASHP system.

Supporting Tribes
In addition to convening the GLIHA energy advisory committee and heat pump training, the Project Team conducted a series of interviews with Tribal housing authorities to understand the challenges and opportunities associated with upgrading Tribal buildings. Based on these findings it was clear that engagement with Tribal partners through implementation of demonstration projects in Tribal housing to highlight installation and use of air source heat pumps is an important part of broader adoption of heat pump technology.

Currently, Elevate has two demonstration projects in process with the Lac du Flambeau Band of Lake Superior Chippewa Indians and Red Cliff Band of Lake Superior Chippewa. The team is implementing a ductless heat pump system in a 10-unt affordable housing building owned and managed by Lac du Flambeau. Part of this project includes indoor air quality monitoring. The project also includes a ground mount solar system with storage to offset the additional electric load from adding cooling to the building as well as provide backup power in the case of a power outage. Similarly, at Red Cliff the team is implementing an air source heat pump system on a duplex. Ongoing Tribal engagement will include portfolio analysis to identify additional opportunities for decarbonization as well as continuing to convene the energy advisory group and conduct additional trainings as part of future GLIHA meetings.

Supporting Middleton and Madison
The Efficiency Navigator programs being administered by Sustain Dane and Elevate in Middleton and Madison have also presented an opportunity for outreach, education and demonstration projects. These programs now include regular communication with owners of small, affordable multi-family rental buildings on efficiency upgrades as well as HVAC upgrades with heat pumps. The motivating factor is the addition of cooling for residents. In Middleton, the program provides owners with up to $60,000 and free technical assistance to conduct deep energy retrofits that include decarbonization measures. Similarly in Madison, a $25,000 subsidy is provided to owners for energy retrofits. Even though the Madison program does not include a requirement for decarbonization, the Efficiency

Navigator program is seeing a greater uptake in heat pump technology because of the education and outreach provided by the free technical assistance. The economic and emission analysis as a part of this project will inform the Efficiency Navigator on the array of heat pump options based on the housing stock and best opportunities for this program based on economic and emission savings.

American Lung Association (ALA) Northern Wisconsin Woodstove Changeout Program
The Project Team learned about the existence of a Northern Wisconsin woodstove changeout program overseen by the American Lung Association and engaged the program manager to learn more about the status of the program and helped spread the word among key stakeholders.

The program launched in 2021 during the middle of COVID-19 reopening and recovery and issued the first vouchers in May 2022. The program is scheduled to close May 2024 or when funds are depleted. As of early May 2023 approximately 40% of grant funds was expended and there was approximately $150,000 remaining funds available. The program manager communicated participating retailers are critical to promotion and implementation. A variety of high-efficient home heating equipment is eligible for vouchers and no ASHPs had received a voucher as of May 2023. Most vouchers redeemed at this point went to cleaner, more efficient wood stoves. Below are eligible voucher amounts for ASHPs.

- **Market-Rate**: $2,500 for ENERGY STAR air source heat pump
- **Income-Qualified**: $4,450 for ENERGY STAR air source heat pump

Most participating retailers focus sales on woodstoves and our team discovered through engagement that many key Wisconsin stakeholders were unaware of this program. Throughout May and June 2023 our team communicated program information to State staff, Focus on Energy Staff, and to manufacturers and distributors that are part of the Wisconsin Heat Pump Coalition to promote more widespread awareness of this program. We encouraged ASHP retailers to participate so that the remaining vouchers will be utilized and can be leveraged to further discount ASHPs for eligible Wisconsin residents. We also communicated findings from the supportive UW-Madison graduate student analysis that switching from woodstove heat may result in approximately $3,700 benefits from health and safety improvements stemming from reduced risk of fires and reduced inhalation of PM2.5 and CO.

Introduced Heat Pump Contractor Designation Concept and Design Considerations with Focus on Energy Staff
As described in the playbook, one of the recommended actions that our team sees as having a major potential impact on ASHP market transformation is for Focus on Energy to adopt a heat pump contractor designation. To further education and understanding, in June 2023 our team met with the Focus on Energy team to provide an overview of this concept, shared resources and examples from other states, and provided some considerations for a Focus on Energy heat pump contractor design.

Focus on Energy has already invested in development of a heat pump customer buying and operational guide and our team communicated how an ASHP contractor designation could help connect customers with committed, qualified, and supportive contractors to foster positive early experiences as this market grows in the coming years. Focus on Energy staff are considering this concept and our Project Team has made ourselves available to answer any follow-up questions from the team.

Initial planning to support Department of Energy, Housing, and Community Resources (DEHCR) on organizing Four Fall 2023 ASHP contractor events across Wisconsin

Upon learning about the success of the Dane County contractor workshop on ASHPs, DEHCR expressed interest in building upon the successful model and planning a series of ASHP events for HVAC contractors and Weatherization Assistance Program (WAP) agency staff across the state in Fall 2023. Our team participated in an initial planning meeting sharing insights for successful events and connected the DEHCR implementation team with the Wisconsin Heat Pump Coalition to share plans with manufacturers and distributors and invite their participation as part of the planning committee. The Wisconsin single-family building stock fuel type analysis was particularly helpful to DEHCR as they planned which parts of the state to provide the event and how the content may need to adjust based on local conditions such as the predominance of propane or natural gas in the area.

CONCLUSION AND NEXT STEPS

Wisconsin has a history of rapid market transformation in residential heating as it led the nation in transitioning to high-efficiency condensing furnaces in the 1980's. The 2020's are shaping out to be the decade of rapid market transformation towards ASHPs. While 2030 is an achievable near-term destination, to meet the State's goal to be carbon free by 2050, carbon-free (likely all-electric) heating solutions will need to be ubiquitously sold by 2035 so that all active residential heating systems are carbon-free by 2050.

This planning project was just the first step but positions Wisconsin well to drive market transformation of this technology. We are eager for Wisconsin stakeholders to utilize findings from this project to continue the momentum to drive meaningful actions and bring environmental, economic, equity benefits in the transition to ASHP technology as the state moves towards decarbonizing residential buildings.

APPENDIX A: DETAILED SCENARIO TABLES

Table 27. Installed cost estimates

Equipment Archetype	Efficiency Ratings	Size (tons)	Equipment Cost	Markup 1 Installed Cost	Markup 2 Installed Cost	Average installed cost
Baseline Cooling (adding new AC)	14 SEER	2	$1,829	$8,038	$8,651	$8,344
Baseline Cooling (replacing AC)	14 SEER	2	$1,829	$8,240	$8,651	$8,445
Window AC	10 SEER	1	$450	$790	$790	$790
Baseline ER Baseboard	99%	5 kW	$589	$4,705	$2,786	$3,746
New Furnace (NC)	95%	3.5	$1,228	$6,404	$5,807	$6,106
Gas Boiler (MF NC)	95%	12.5	$8,413	$20,564	$29,836	$25,200
New furnace (with Retrofit)	95%	3	$1,041	$5,637	$4,922	$5,280
Single/ Two-stage ASHP	15 SEER, EER 12.5, HSPF 8.2	2	$1,918	$8,522	$9,067	$8,795
Average VSHP (propane)	SEER 16.5, EER 10.6, HSPF 9	3	$3,963	$13,649	$18,737	$16,193
Average VSHP (natural gas)	SEER 15, EER 11.5, HSPF 9	2	$3,963	$13,613	$18,737	$16,128
ccASHP	SEER 17, EER 12.5, HSPF 9.5	2.5	$6,231	$17,763	$29,462	$23,612
Ductless HP (SF NC)	SEER 23, EER 15.2, 12.5 HSPF	2	$2,475	$8,972	$11,703	$10,338
Ductless HP (MF Retrofit)	SEER 23, EER 15.2, 12.5 HSPF	1.5	$2,308	$8,653	$10,912	$9,782
Ductless HP (MF NC)	SEER 23, EER 15.2, 12.5 HSPF	1	$1,875	$7,838	$8,865	$8,351

Table 28. Annual operational cost savings by fuel type - Ashland

Case	Electric	Gas	LPG	Total
SF NG DF 2sASHP	($137)	$270	$0	$133
SF NG DF vsASHP	($94)	$270	$0	$176
SF NG DF ccASHP	($106)	$270	$0	$164
SF Propane DF 2sASHP	($264)	$0	$945	$681
SF Propane DF vsASHP	($933)	$0	$2,353	$1,420
SF Propane DF ccASHP	($1,250)	$0	$2,489	$1,239
SF All Electric NC	($1,316)	$735	$0	($581)
MF DHP Retrofit	$616	$0	$0	$616
MF All Electric NC	($355)	$188	$0	($168)

Table 29. Annual cost savings by fuel type - Milwaukee

Case	Electric	Gas	LPG	Total
SF NG DF 2sASHP	($131)	$249	$0	$118
SF NG DF vsASHP	($80)	$250	$0	$170
SF NG DF ccASHP	($94)	$250	$0	$156
SF Propane DF 2sASHP	($528)	$0	$1,455	$926
SF Propane DF vsASHP	($759)	$0	$2,024	$1,265
SF Propane DF ccASHP	($992)	$0	$2,123	$1,131
SF All Electric NC	($1,036)	$623	$0	($412)
MF DHP Retrofit	$544	$0	$0	$544
MF All Electric NC	($258)	$152	$0	($107)

Table 30. Annual cost savings by season – Ashland

Case	Heating	Cooling
SF NG DF 2sASHP	$121	$11
SF NG DF vsASHP	$151	$26
SF NG DF ccASHP	$141	$22
SF Propane DF 2sASHP	$670	$11
SF Propane DF vsASHP	$1,394	$26
SF Propane DF ccASHP	$1,217	$22
SF All Electric NC	($601)	$20
MF DHP Retrofit	$607	$8
MF All Electric NC	($183)	$15

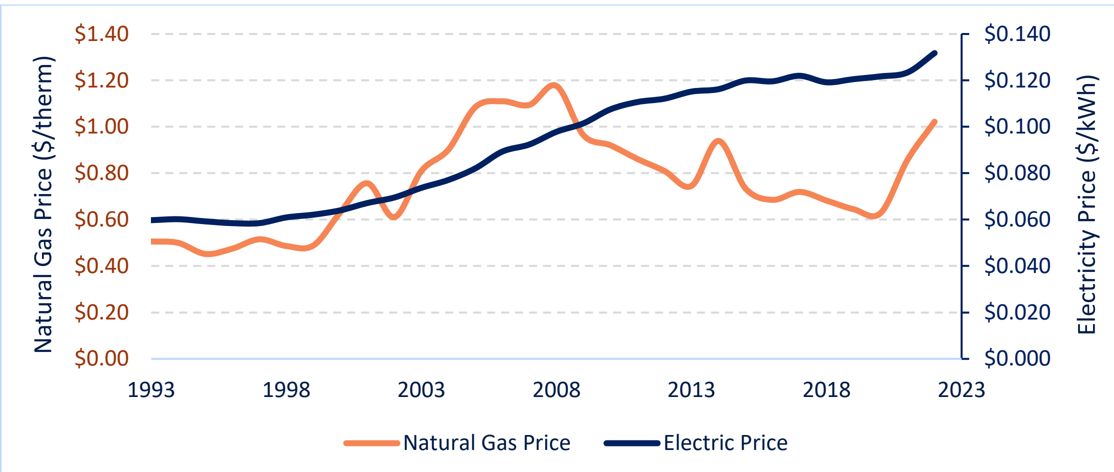
Table 31. Annual cost savings by season – Milwaukee

Case	Heating	Cooling
SF NG DF 2sASHP	$103	$15
SF NG DF vsASHP	$129	$40
SF NG DF ccASHP	$120	$35
SF Propane DF 2sASHP	$911	$15
SF Propane DF vsASHP	$1,222	$43
SF Propane DF ccASHP	$1,095	$35
SF All Electric NC	($452)	$40
MF DHP Retrofit	$529	$15
MF All Electric NC	($133)	$26

APPENDIX B: PRICING SENSITIVITY

While retrofits for customers with propane or electric resistance heat are likely to remain cost effective because propane is expensive and electric prices tend to increase, the economic viability of cases where we compare to natural gas is highly dependent on fuel prices. For our analysis, we used rates from 2022, the most recent complete year of data. Natural gas prices are subject to short- and long-term volatility, and the Project Team recognizes that rates spiked in the winter of 2021/2022 and 2022/2023. By comparison, electricity rates tend to increase slowly over time as shown in Figure 5. EIA forecasts indicate that this number may come down across 2023 and into 2024[19], but heat pumps have a lifetime of over 15 years over which prices may continue to change.

Figure 5. Electricity and natural gas prices in Wisconsin, 30 years of historical data[20]



The combination of natural gas and electricity prices determine the economic switchover or bill parity temperature for dual fuel cases and determines the cost effectiveness of all other scenarios, as follows:

- **Single-family Natural Gas Dual Fuel Retrofit:** Higher natural gas prices will allow the heat pump to save money when running at lower temperatures, and will increase savings from the higher efficiency installed furnace. This could change the economic switchover temperature. Higher electric rates result in more cooling savings compared to the baseline. By contrast, lower electric rates would result in more heating savings from switching to heat pump operation.
- **Single-family Propane Dual Fuel Retrofit:** Savings are proportional to propane costs and inversely proportional to electric rates.
- **Single-family All-Electric New Construction:** Gas prices affect the counterfactual operating costs of a ducted furnace and air conditioner, while electric prices affect the system operation costs.
- **Multi-family All-Electric New Construction:** Gas prices affect the counterfactual operating costs of a gas boiler and air conditioner, while electric prices affect the system operation costs.

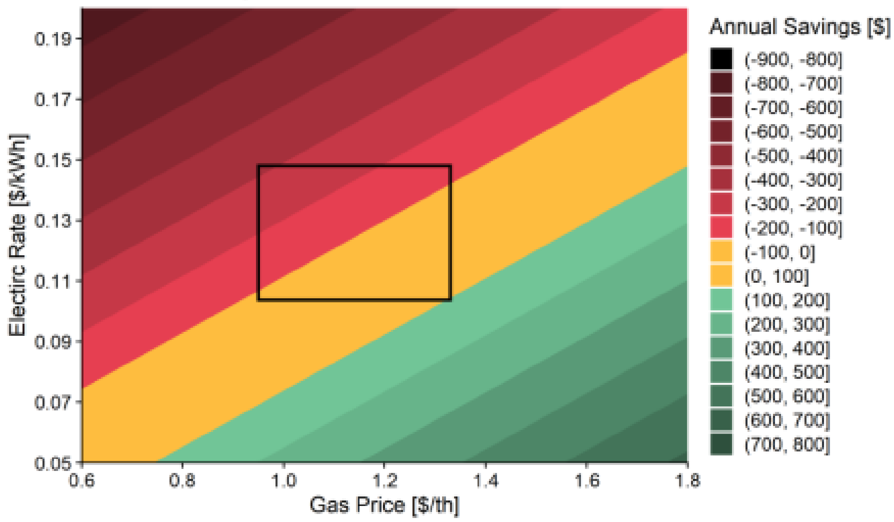
[19] "EIA forecasts lower wholesale U.S. natural gas prices in 2023 and 2024," https://www.eia.gov/todayinenergy/detail.php?id=55219

[20] Source: U.S. Energy Information Administration. https://www.eia.gov/dnav/ng/hist/n3010wi3a.htm

- **Multi-family Electric Resistance Retrofit:** Savings are directly proportional to electricity costs, because heat pump installation only saves electricity.

Figure 6, from Center for Energy and Environment's whitepaper on hybrid heat pump rates[21] shows this relationship for the Single-Family Natural Gas Dual Fuel Retrofit scenario. As shown in the contour plot, higher gas prices and lower electricity prices result in savings scenarios, whereas the opposite combination results in bill increases.

Figure 6. Contour plot of potential savings outcomes for a range of electric and gas rate combinations in Wisconsin



In addition to rates sensitivity by utility and year, annual savings potential is highly sensitive to the nature of each individual case. The Project Team modeled median cases to estimate typical savings, but individual residences will vary above and below our estimates. Some factors that may strongly influence costs include:

- **ASHP heating efficiency and heating capacity profiles over different outdoor air temperatures**. This study only included a few model archetypes and do not reflect the diversity of performance of ASHPs based on equipment models, design, and installation quality. In general, we attempted to reflect field performance, but various studies have shown that field performance can vary widely.

- **Availability of natural gas and gas hookup fees:** Depending on the distance from existing infrastructure and the type of property, gas hookups could be cheaper, substantially more expensive, or impossible. Those differences impact the counterfactual to a heat pump, potentially making the choice more economical.

- **Contractor network familiarity:** In areas where there are existing seasoned heat pump installers, cost of installation will be lower than the estimates provided. In areas where a contractor would be installing the heat pump as a rarity installation costs will be higher.

[21] https://www.mncee.org/developing-electric-rates-hybrid-air-source-heat-pumps-midwest

Moreover, it is likely that more contractors with more familiarity will deliver higher quality installations, which impacts system efficiency and future savings. They may also be able to suggest systems that fit better with existing building needs.

- **Building characteristics:** Due to declining costs with larger boilers, smaller multi-family buildings may be a better fit for heat pumps in new construction, and single-family buildings that have undergone weatherization may be able to meet more of their heating needs with a heat pump sized for existing ductwork. The size of the ducts themselves, or the presence of an existing hydronic system, impacts the choice of heat pump. Room layout also impacts the number of ductless units to provide comfortable heating and cooling, which has cost implications.

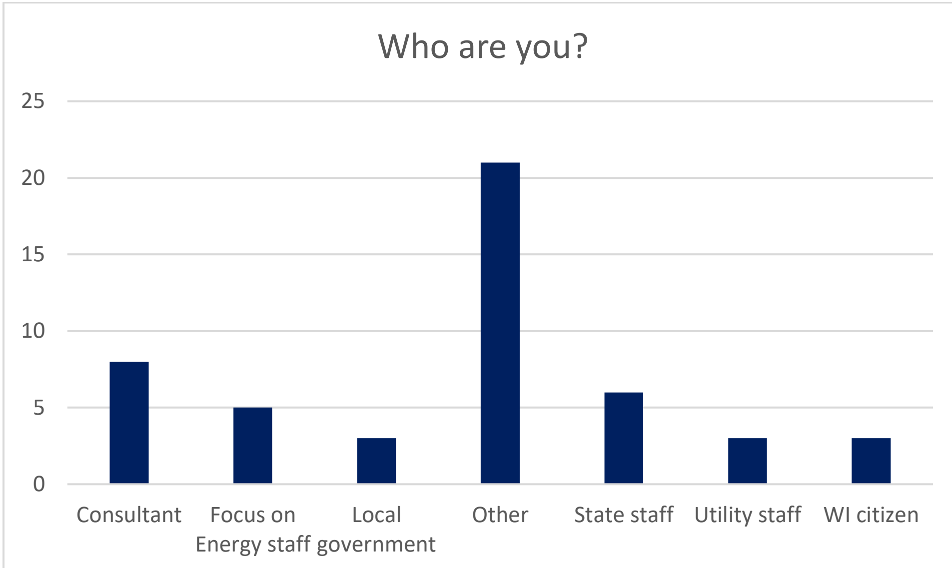
APPENDIX C: MARKET TRANSFORMATION PLANNING MURAL BOARD

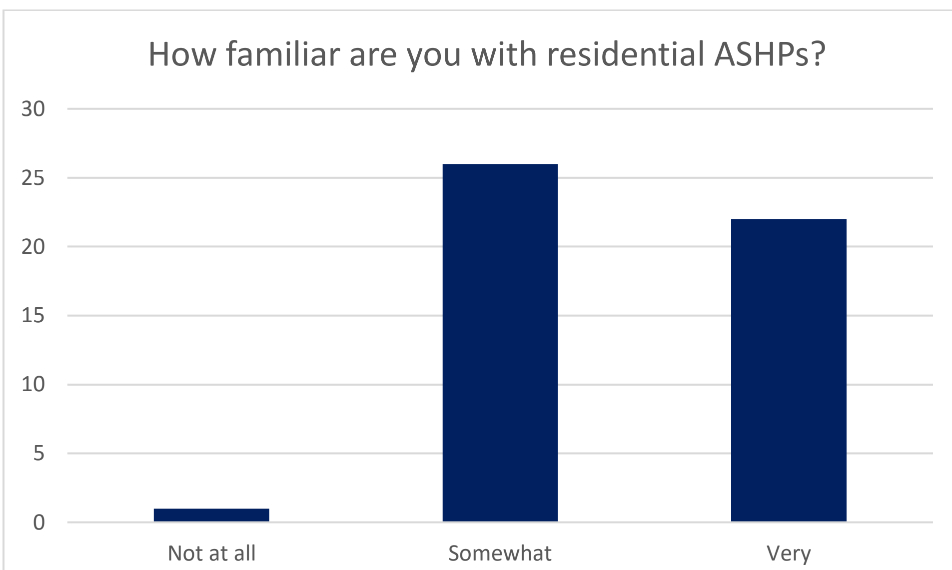
The attachment below contains the Mural planning board for the market transformation roadmap. Version 3 represents the final version the Project Team utilized for the market transformation playbook.

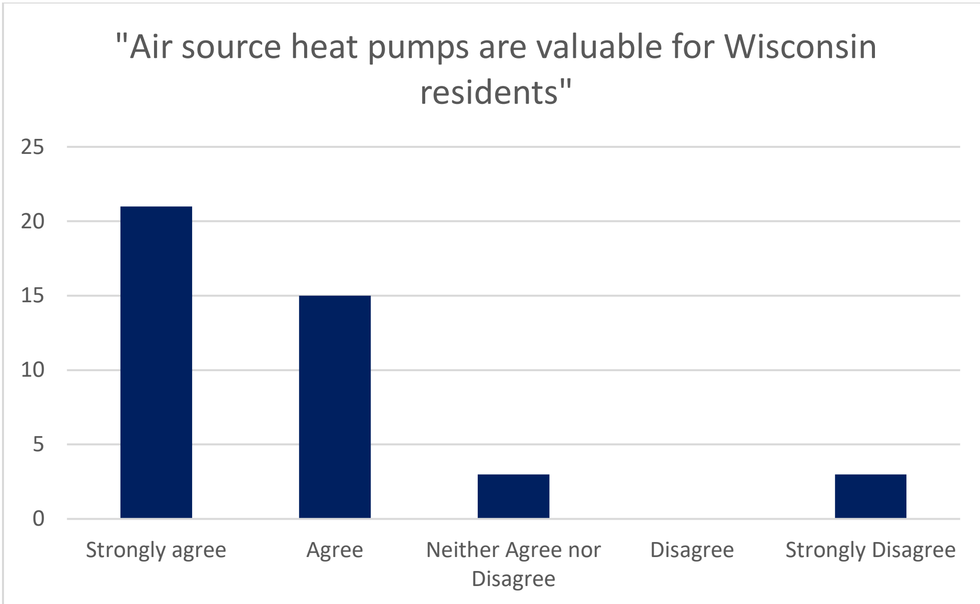
WI ASHP Market
Transformation Road

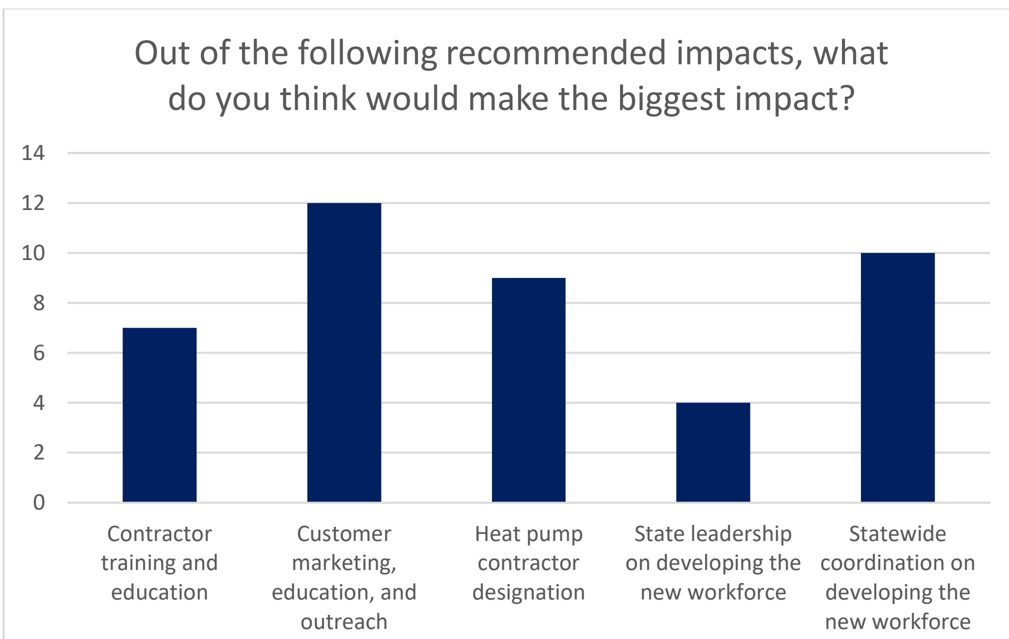
APPENDIX D: PLAYBOOK WEBINAR ATTENDEE RESPONSES

Below are graphs of data collected from attendees through polls and a post-webinar survey. Four poll questions were asked of live attendees and below are results:

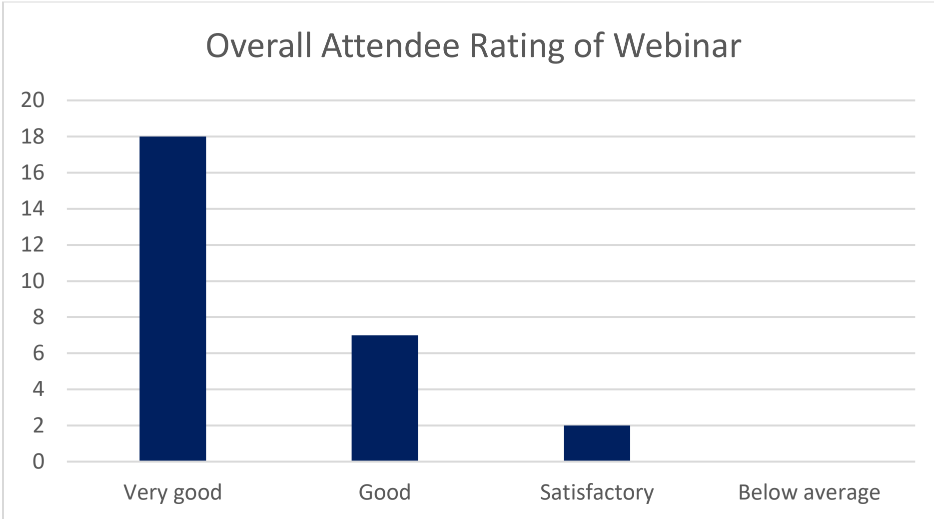


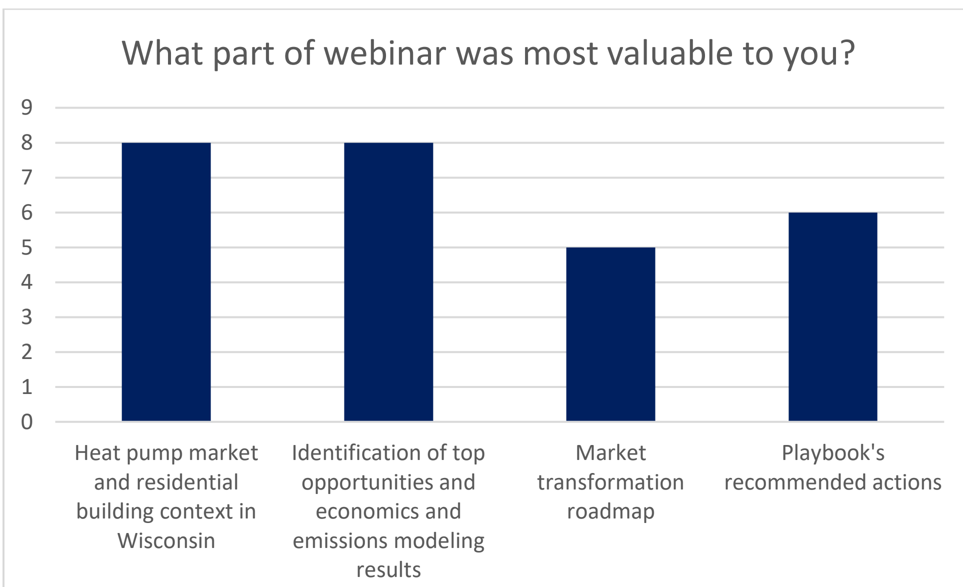






Below are responses from the webinar survey that was delivered upon completion.


Overall Attendee Rating of Webinar
20
18
16
14
12
10
8
6
4
2
0
Very good
Good
Satisfactory
Below average


What part of webinar was most valuable to you?
9
8
7
6
5
4
3
2
1
0
Heat pump market and residential building context in Wisconsin
Identification of top opportunities and economics and emissions modeling results
Market transformation roadmap
Playbook's recommended actions