In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 code/energy hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

For additional continuing education approvals, please see the continuing education credit section in the conference agenda booklet.

Heat Pumps 101

Cold Climate Air Source Heat Pumps: A Primer and Launch Pad

Dan Wildenhaus
Rabi Vandergon

ASHP
air source heat pump collaborative

Discussion goals

- Unpack rising potential for heat pumps
- Validate equipment works in cold climates
- Benefits and considerations using cold climate ASHPs
- Sizing and design considerations
- Installation considerations and common pitfalls
- Comparisons by application types

Image credit: https://www.deviantart.com/bouzid27/art/Mountain-Everest-Nepal-Himalaya-1-681356456

Quick poll – who is in the audience?

- Builders
- Contractors
- Local government
- Raters / Energy Auditors
- Weatherization Assistance Providers
- Utility Staff
- Implementers
- Researchers
- Others?

Image source: http://essentialschools.org/join/

Quick poll – who here is considering getting a heat pump?

- Why?
  - Decarbonize home
  - Equipment is at/near end life
  - Sweet, sweet IRA money is coming!
  - Other reasons?

At our core

PROGRAMS

We cut energy waste and improve comfort in homes, buildings, and communities.

RESEARCH

We identify cost-effective, efficient technologies through analysis, modeling, and engagement.

CONSULTING

We help building owners and entire communities achieve long-term, energy-saving solutions.

LENDING

We empower people to make upgrades on energy efficiency and comfort in homes or businesses.

POLICY

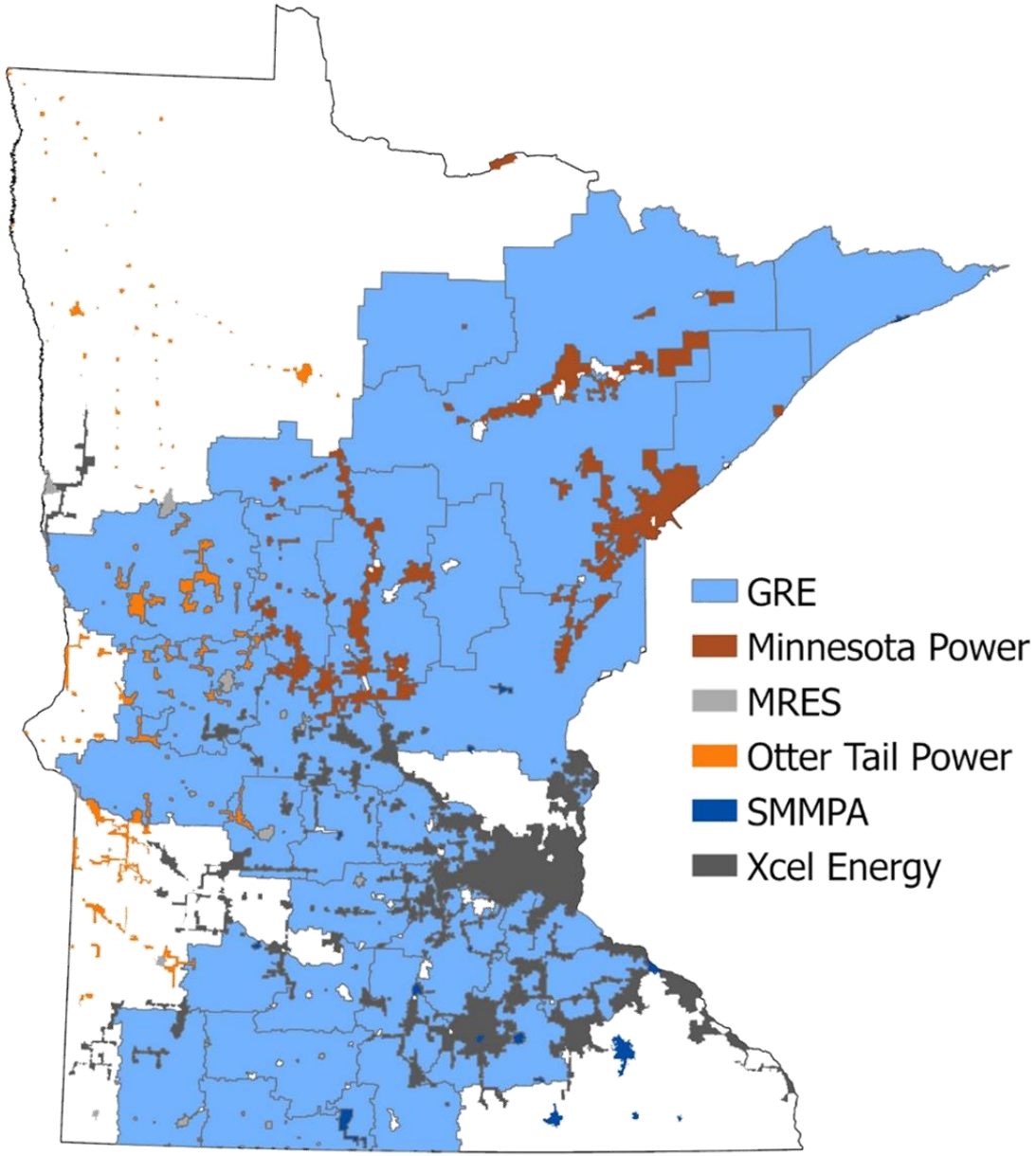
We strive for high-impact, pragmatic solutions guided by a public interest ethic.

MARKET TRANSFORMATION

We accelerate adoption of promising technologies through early market engagement.

cee
Center for Energy and Environment

MN ASHP Collaborative

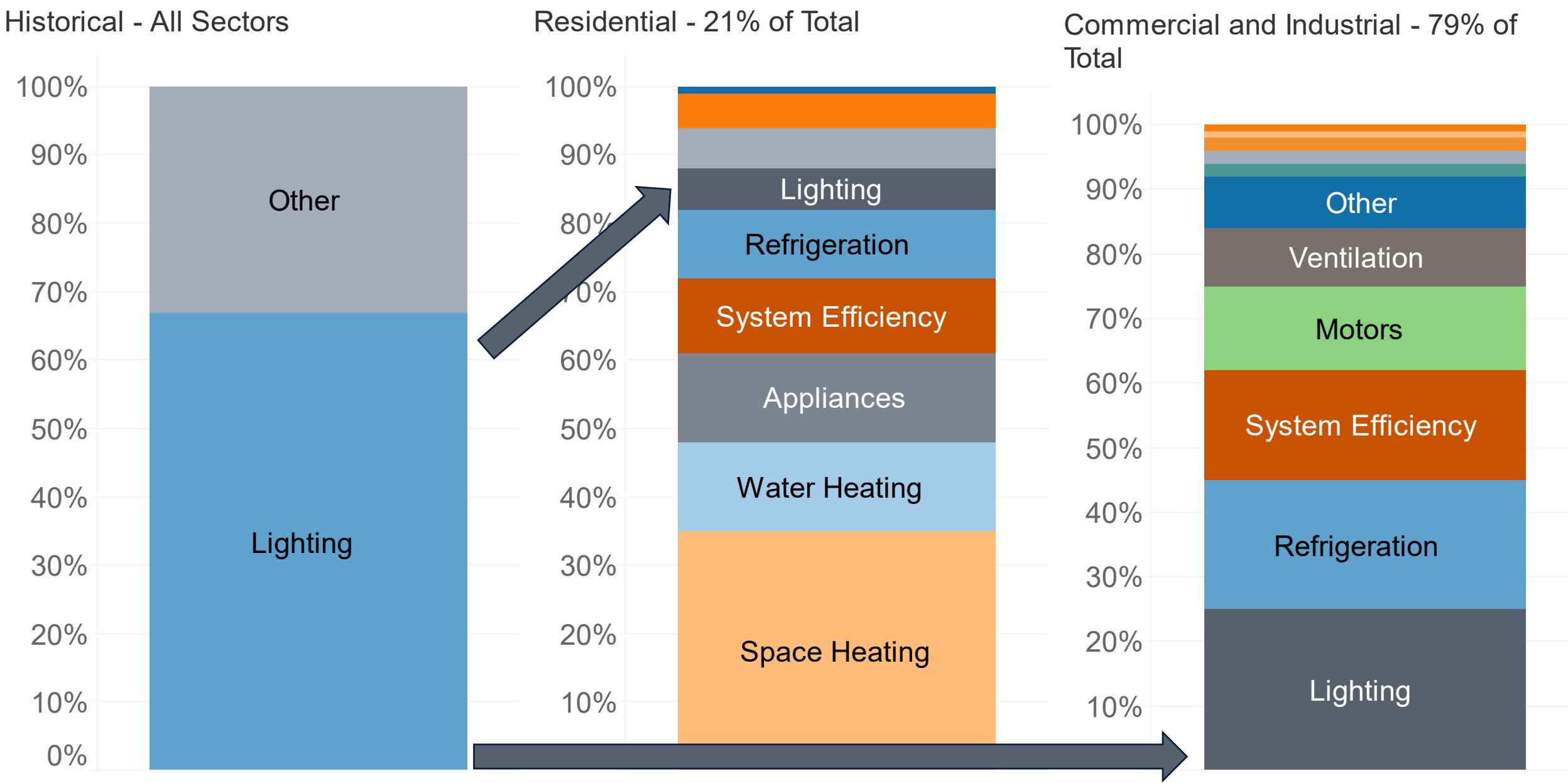


- Launched by CEE in 2019 to accelerate adoption of ASHPs in MN:
- High opportunity for delivered fuels and electric heat customers in rural MN
- Investor-owned, cooperative, and municipal utilities contribute funding
- Following ECO and ETA legislation, programs are expanding to new application types including dual fuel ASHPS in 2023

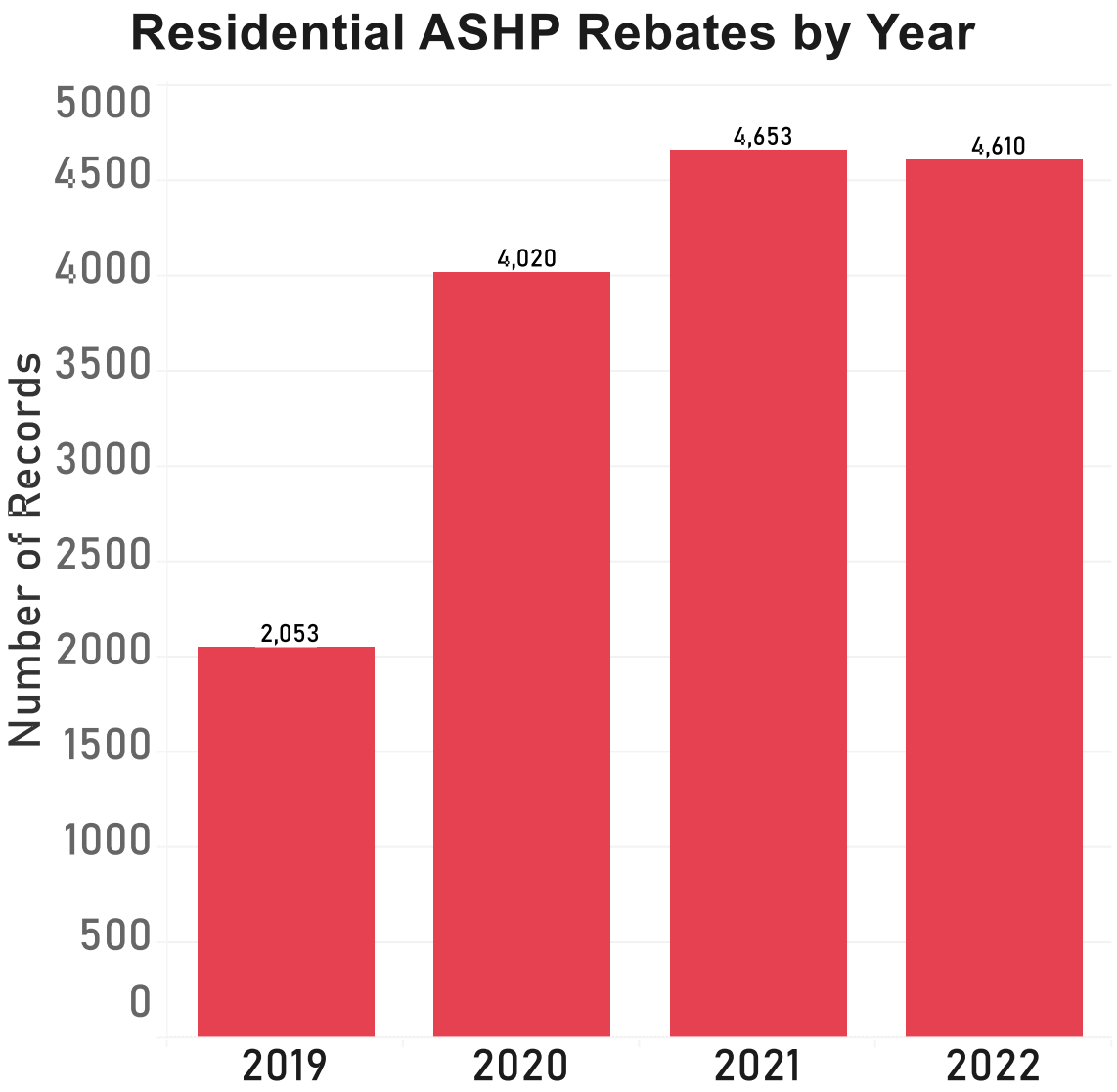
Minnesota Energy Resources
CenterPoint Energy
Great River Energy
Missouri River Energy Services
Southern Minnesota Municipal Power Agency
Otter Tail Power Company
Xcel Energy
Minnesota Power

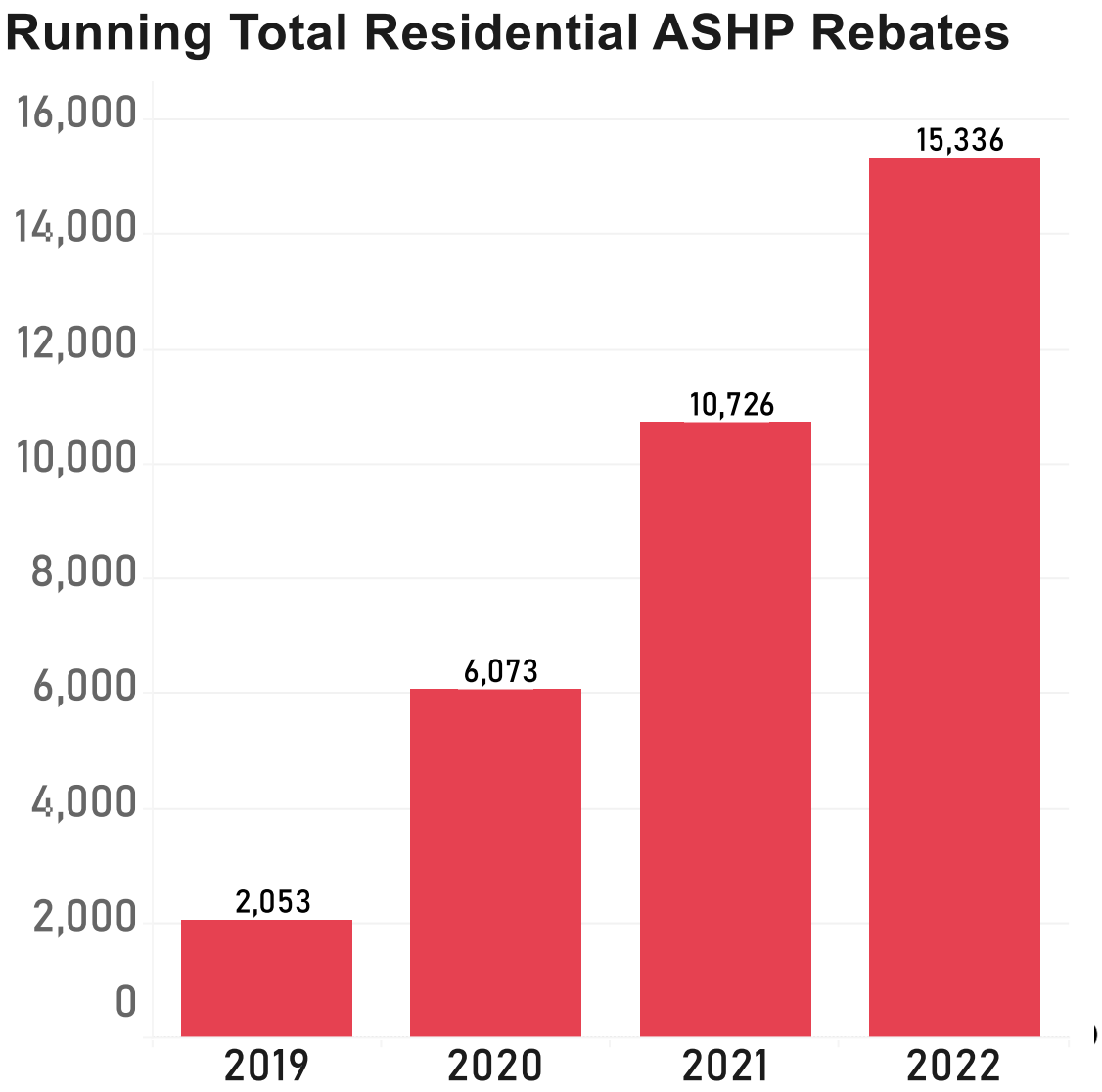
Air source heat pumps have great potential in MN

Minnesota Statewide Electric Savings Potential 2020-2029



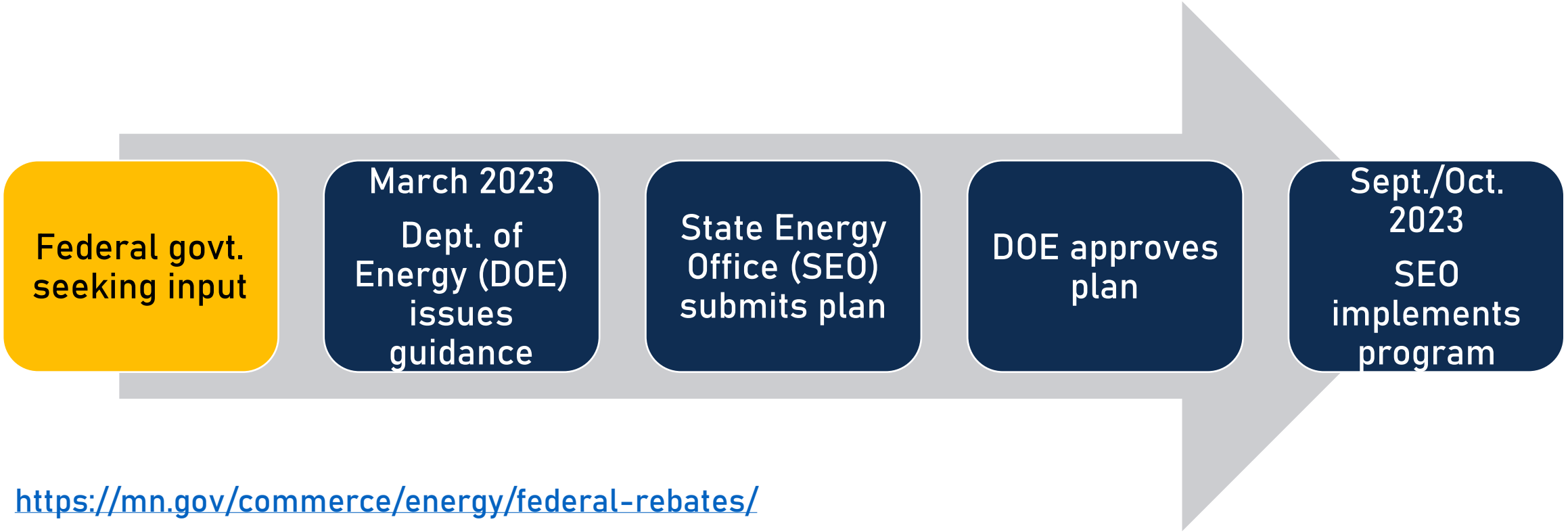
MN heat pump market growth in utility rebate data through 2022





Inflation Reduction Act of 2022

- $2,000 Tax Credit for qualifying ASHPs (25C) through 2032
- Statewide home energy rebates (HOMES and HEEHRA)



https://mn.gov/commerce/energy/federal-rebates/

Energy Conservation and Optimization (ECO) Act

Bipartisan effort will expand heat pump opportunities and grow the market

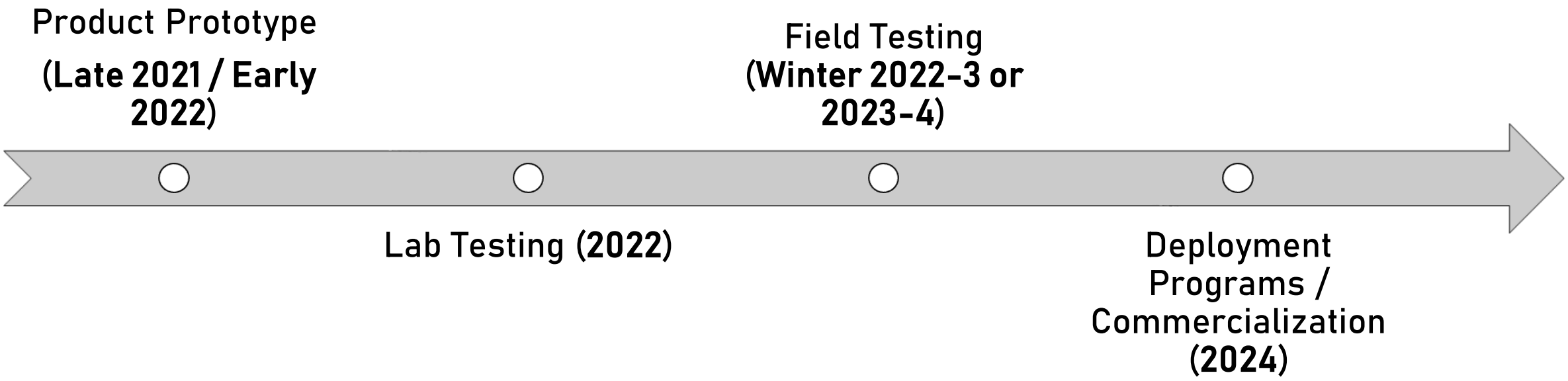
- By June 2023, Minnesota's energy utilities will file their 2024–2026 ECO triennial plans
- Will create new rebates for efficient fuel switching (EFS)

Read more: https://www.mncee.org/cip-eco

Go deep: https://www.mncee.org/minnesota-energy-dockets

DOE Residential Cold Climate Heat Pump Challenge

- Encourages manufacturers to design ccASHPs optimized for 5°F and -15°F
- Manufacturer participants: Bosch, Carrier, Daikin, Johnson Controls, Lennox, LG, Midea, Mitsubishi Electric, Rheem, Trane



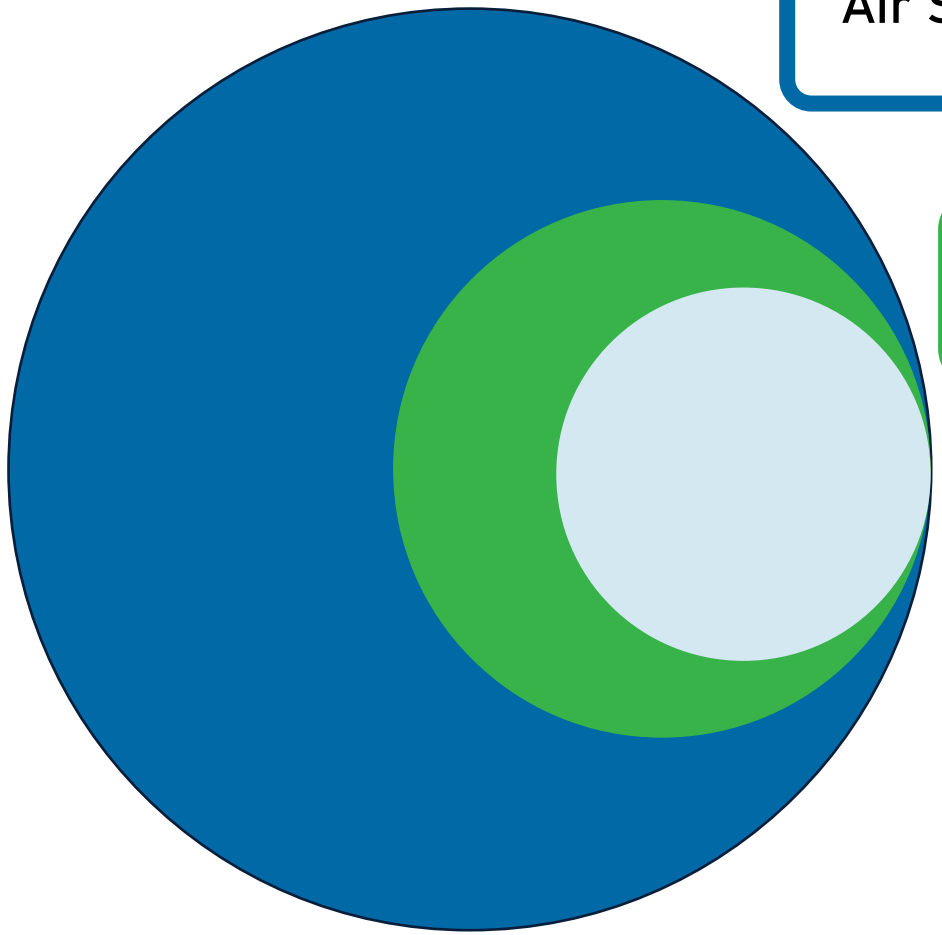
https://www.energy.gov/eere/buildings/residential-cold-climate-heat-pump-challenge

Growing potential

- Rebates shifting from lighting to space heating 2020-2029
- Utility rebate data show the market is already growing
- ECO Act will create new fuel switching rebates in 2024
- Tax credits and rebates in the IRA to increase demand
- Better equipment on horizon through DOE Cold Climate Heat Pump Challenge

Level Setting Terminology

The many names of a heat pump



Air Source Heat Pump (ASHP)

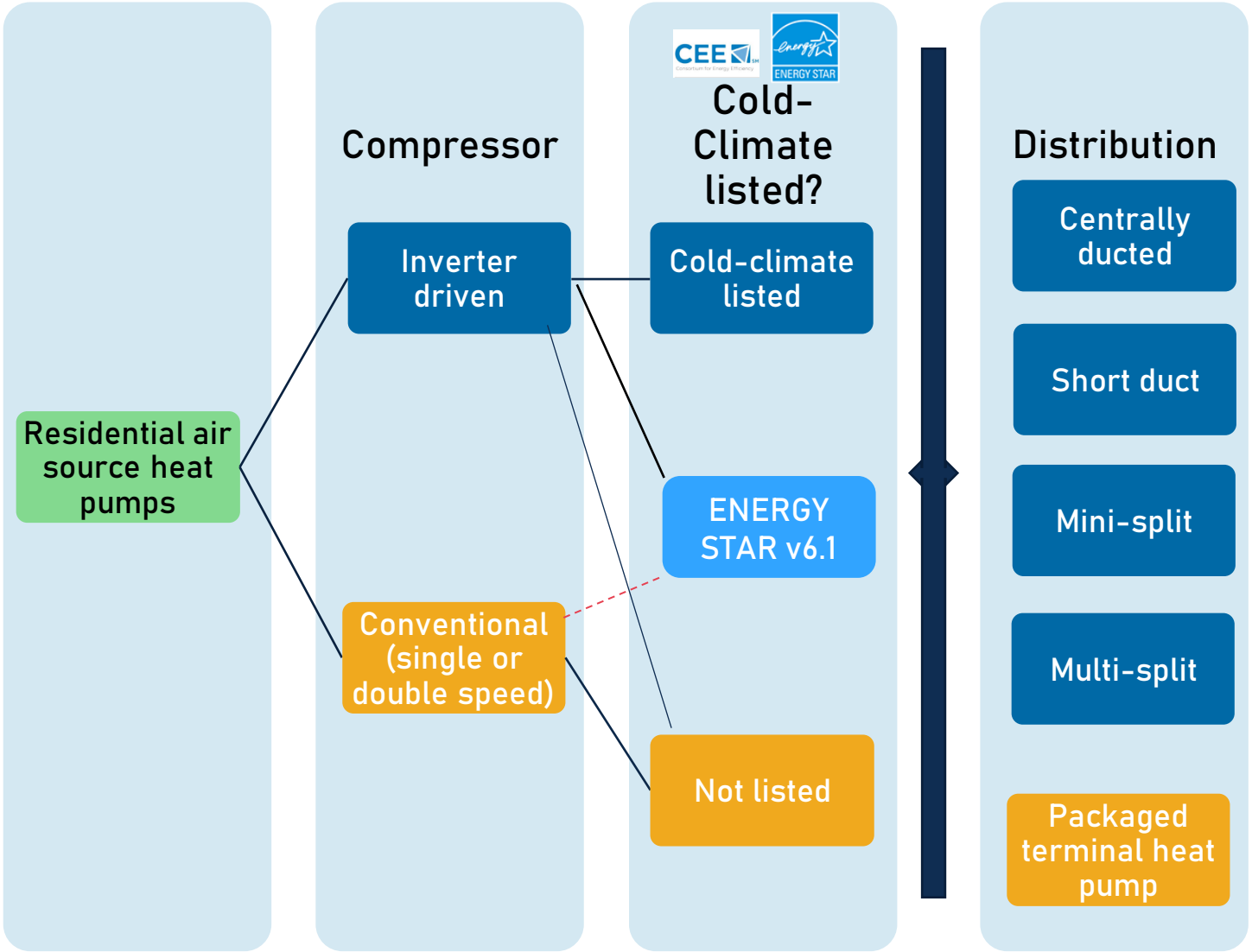
Variable Capacity Heat Pump (VCHP)
Variable Speed Heat Pump (VSHP)

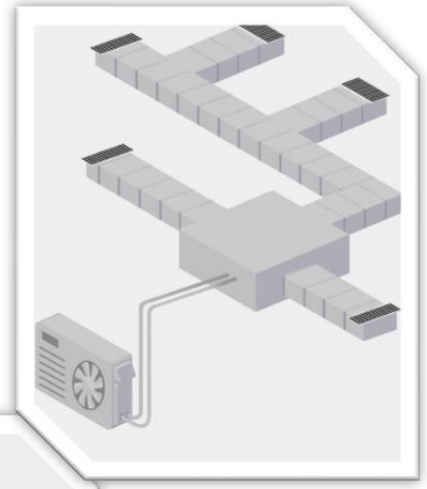
Cold Climate Air Source Heat Pump (ccASHP)

Also Known As:

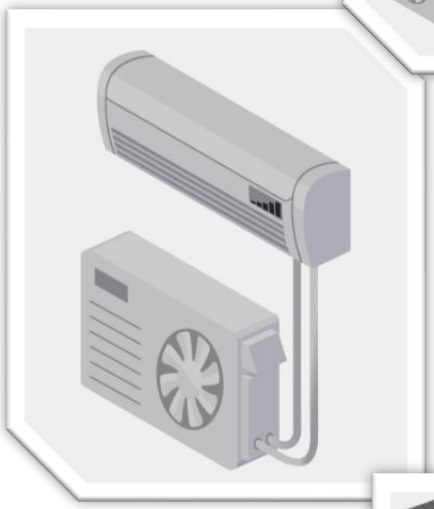
- Inverter driven (for VCHP or VSHP)
- Extended capacity
- Extra performance
- Extreme climate
- Various branded trade-names:
  Hyper heat®, Aurora ®, Halcyon XLTH ®, Max-Heat ®

Heat Pump Taxonomy

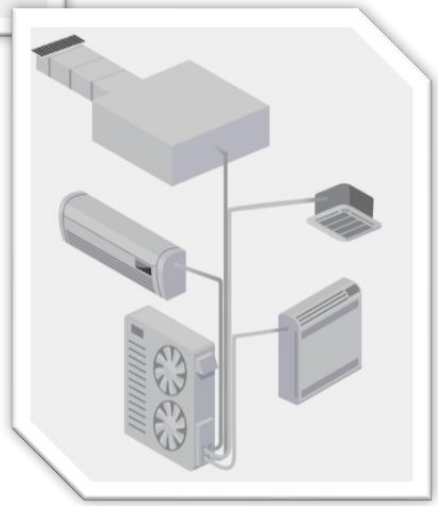




Ducted



Mini-split



Multi-split

Heat Pump Efficiency Ratings Changing

2023: New rating procedure “M1”

Type	HSPF2 (HSPF)	SEER2 (SEER)
AC		13.4 (14)
Heat Pump	**7.5 (8.8)**	**14.3 (15)**
Packaged Units	6.7 (8.0)	13.4 (14)

https://www.resnet.us/about/standards/minhers/draft-pds-01-minhers-addendum-71-seer2-hspf2-conversions/

Cold Climate Specifications 1

"North and Canada" Climate Air Source Heat Pumps (Tier 1 split ducted, Tier 2 non-ducted)

- Capacity ratio of ≥58% at 17°F/47°F OR **≥70% at 5°F/47°F**
- AHRI matched system must be rated (≥ **8.1 HSPF2 ducted,** 9.5 **HSPF2 ductless**)
- **EER2 ≥ 10 ducted, ≥ 9 ductless**
- Optional Demand Response criteria included
- **High efficiency even at 5°F (COP ≥ 1.75)**

CEE1 Heat Pump Tiers - **Aligns with 25C Tax Credits**

ENERGY STAR v6.1 Cold Climate Heat Pump

- Minimum **HSPF2 of 8.5 and SEER2 of 15.2** or greater for **ductless systems**
- Minimum **HSPF2 of 8.1 and SEER2 of 15.2** or greater for **ducted systems**
- Deliver **≥70% of rated capacity at 5°F**
- High efficiency even at **5°F (COP ≥ 1.75)**
- **Perform controls verification procedure to ensure performance is achieved at 5°F with native controls**

ENERGY STAR v6.1 Product Specification for CAC and HP Equipment

Cold Climate Specifications 2

NEEP'S COLD CLIMATE AIR SOURCE Heat Pump List

- Variable capacity, residential-scale, air source heat pump. Ducted or ductless
- High rated heating efficiency (≥ **8.5 HSPF2 ductless, ≥ 7.7 HSPF2 ducted**)
- High efficiency even at **5°F (COP ≥ 1.75)**
- Highly rated cooling efficiency (≥ 8.5 SEER2 ductless, ≥ 14.3 SEER2 ducted)
- Capacity and efficiency data reported at multiple operating conditions

https://ashp.neep.org/#!/

US DOE Residential Cold Climate Heat Pump Challenge

- Centrally ducted units with a minimum of three speeds
- Must have **100% of 47°F capacity at 5°F**
- Low temperature cutoff of -10°F or lower
- Minimum **HSPF2 of 8.5 or greater**
- Minimum 30% delta between minimum capacity and nominal capacity at 47°F

https://www.energy.gov/eere/buildings/cchp-technology-challenge-specifications

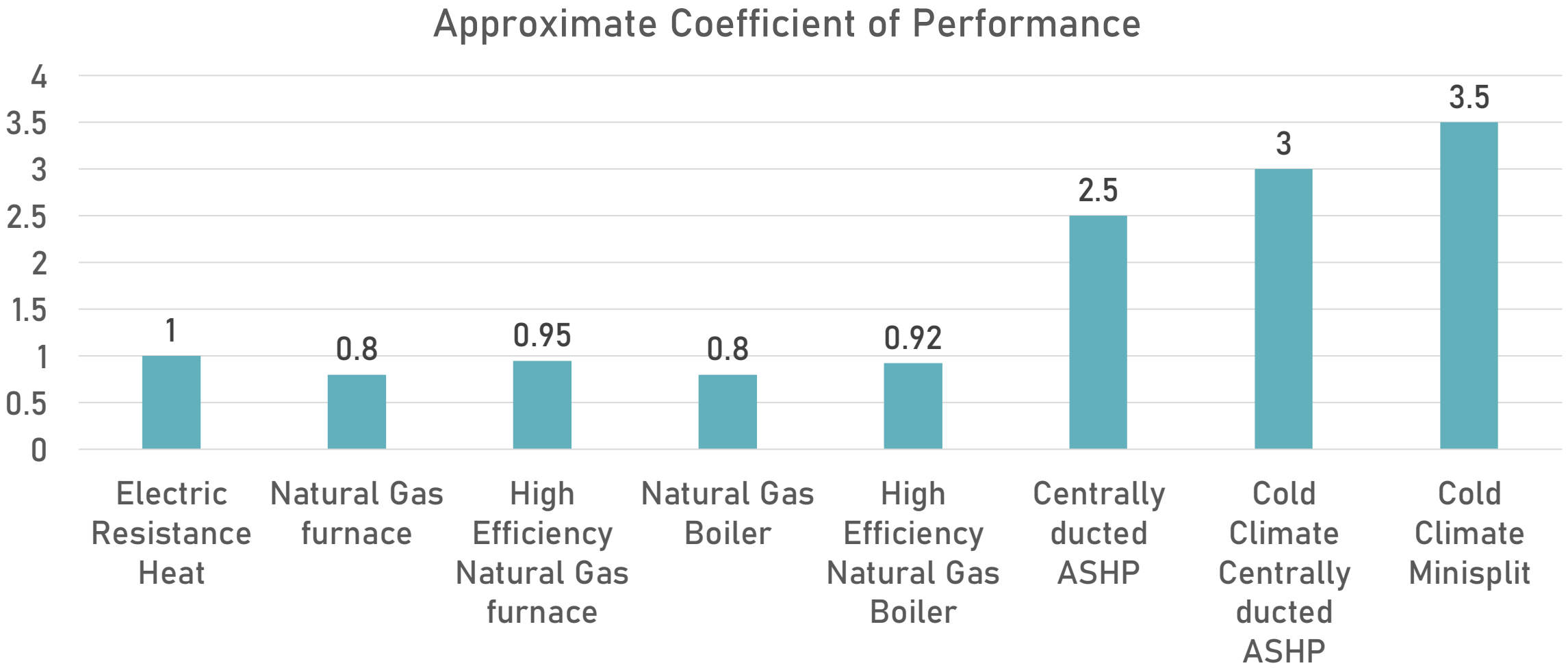
Do ASHPs work well in cold climates?

CEE ccASHP Research Overview

- ***In-field performance studies***
- ***Market studies***
- ***Customer economics & rates***
- ***Informing utility program design***

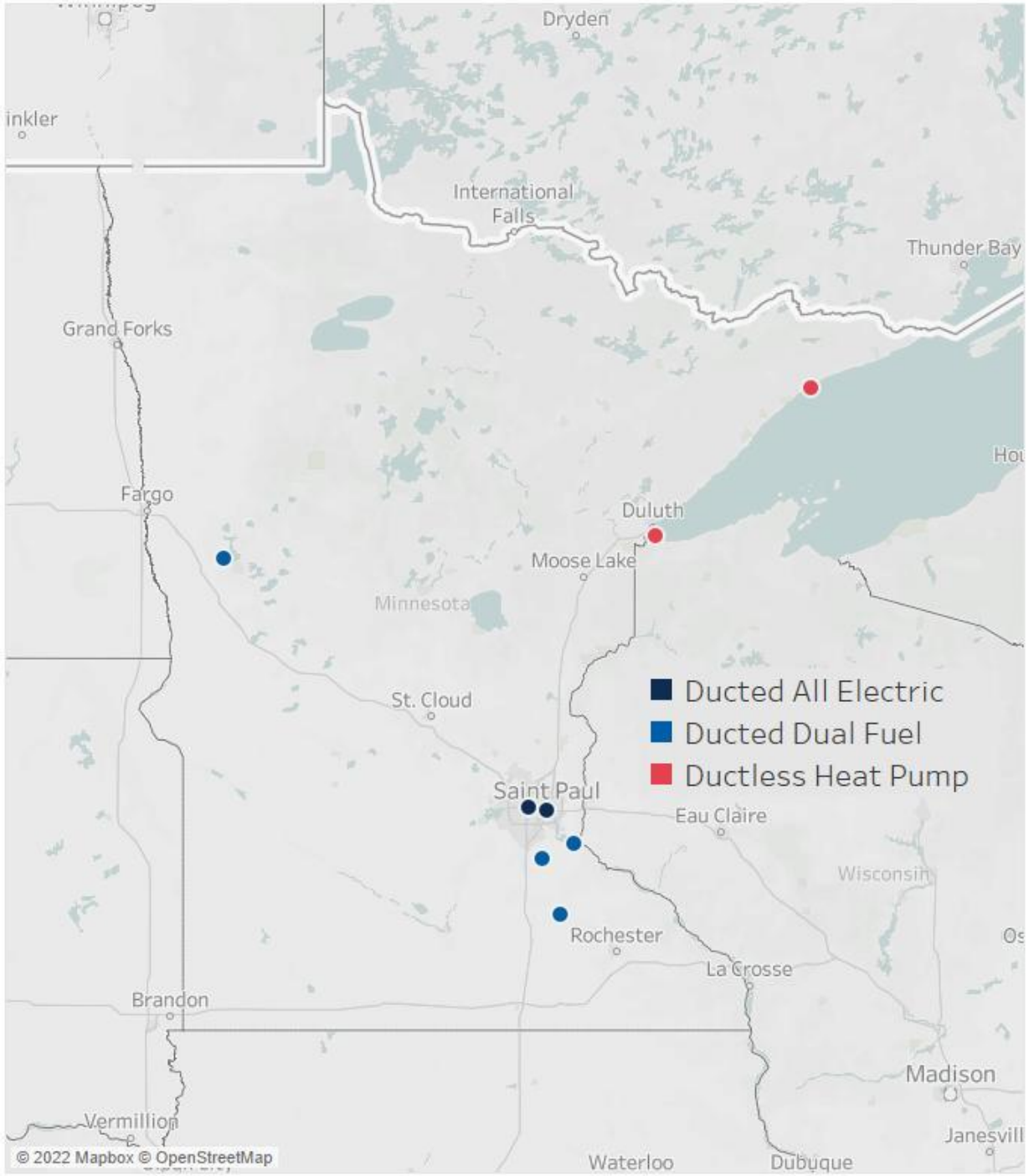
2015–2018	Single family ccASHP field study (*State of MN CARD grant*) and Xcel
2019	MN Potential Study
	CARD single family ccASHP optimization study
	CARD multifamily ccASHP study
2020	ComEd ASHP research study
	NEEA ASHP modeling tool
2021	Heat pumps for AC – multiple projects
	CARD air to water heat pump study

Comparing system types using COP

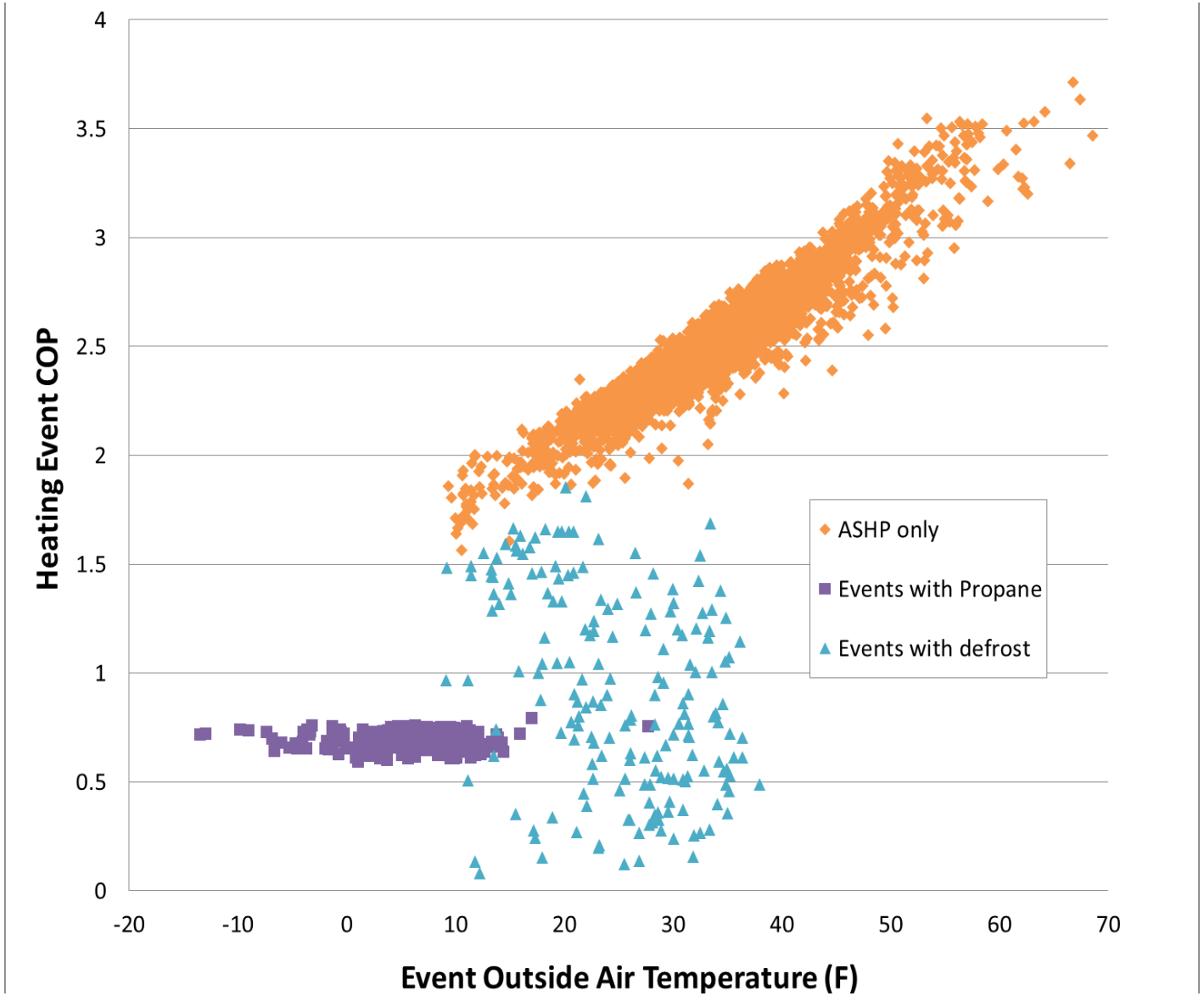


CEE research study overview

- Field Study
  - 8 ccASHPs in a variety of MN residences
    - 6 ducted whole house systems
    - 2 ductless mini-split systems
  - Monitor installed field performance of ASHP & backup
- Each site had detailed data collection
- Installs in climate zones 6 & 7

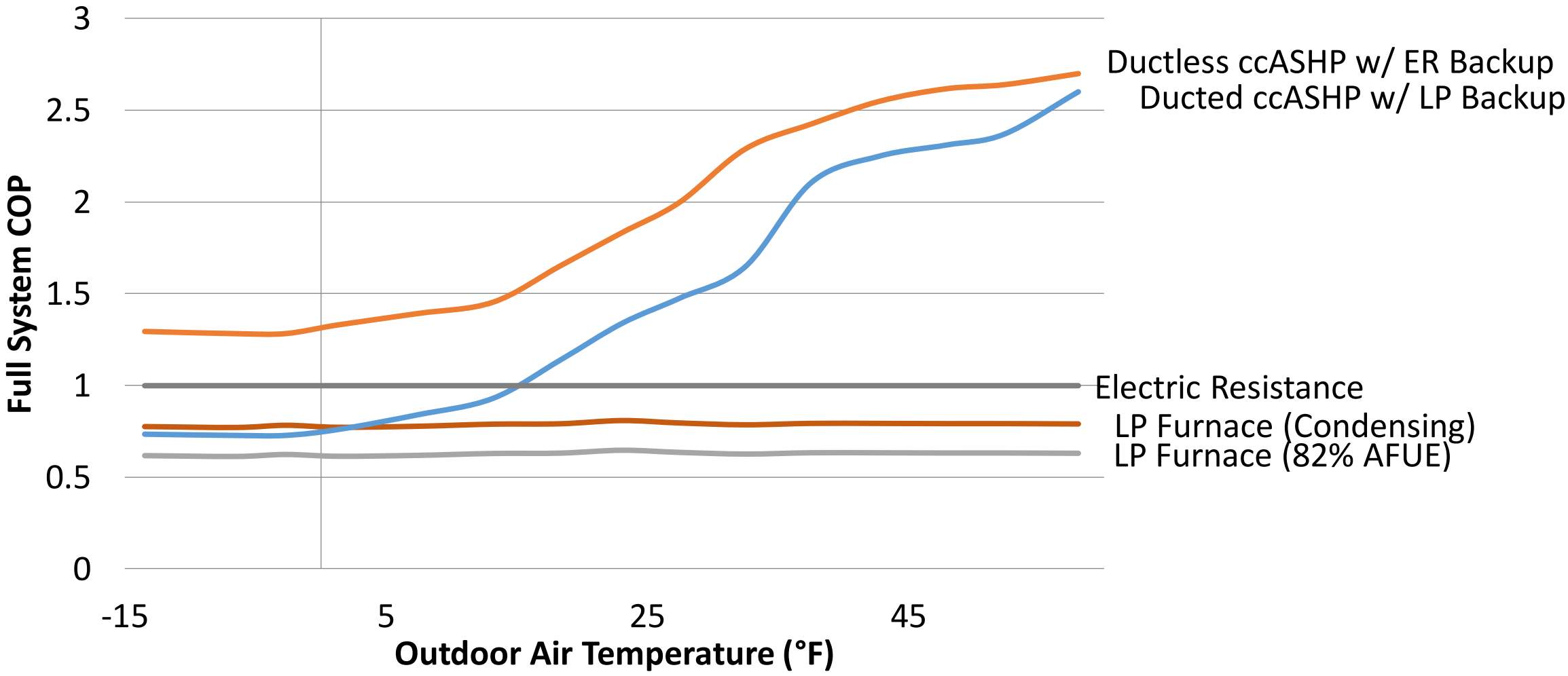


Heating Cycle COP of Dual Fuel System



System performance: measured annual COP

- All-electric, ductless ccASHP **~1.9 to 2.1**
- Dual fuel, ducted ccASHP w/ LP Backup: **~1.2 to 1.3**



CEE's field research results

✓Significant savings for replacing propane and electric resistance

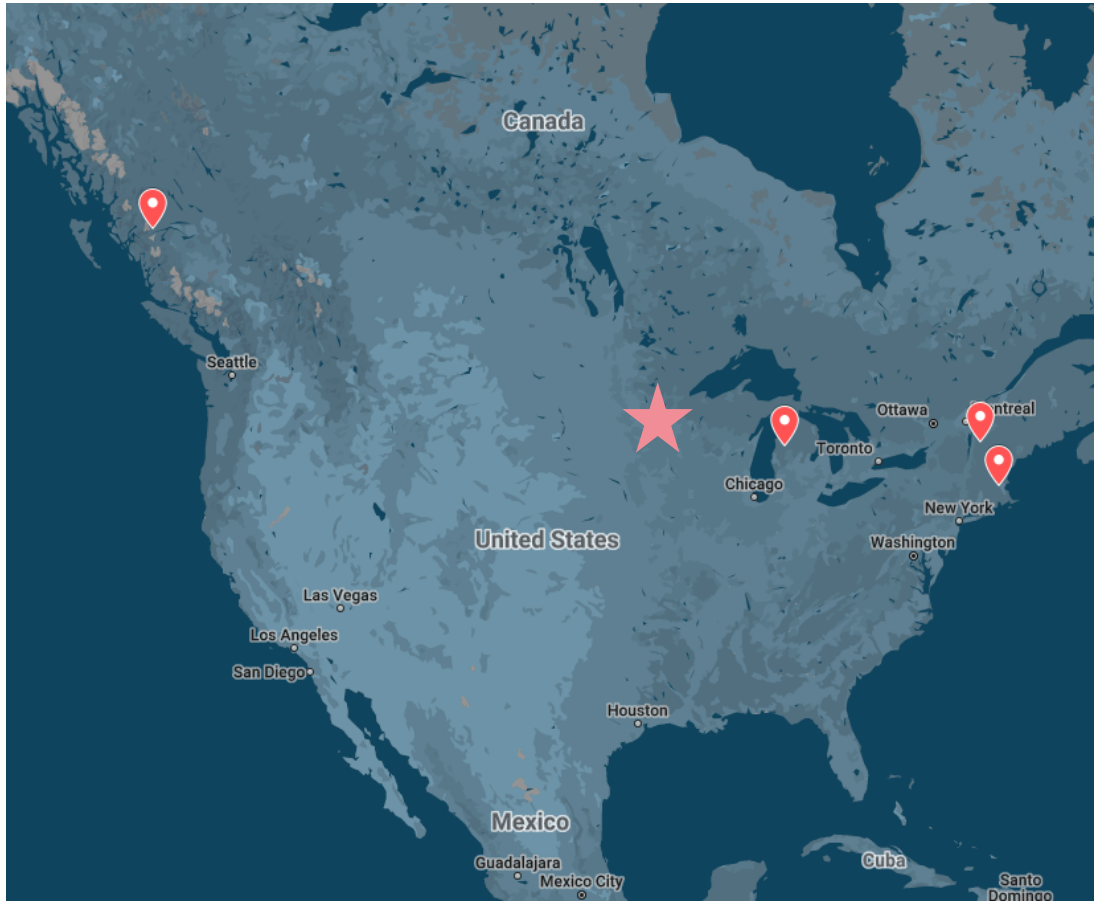
Annual Reductions for ccASHPs				
	Site energy	**Source energy**	**Homeowner cost**	**Emissions**
Dual-fuel ASHP vs. propane furnace	40%	10%	30%	5%
All-electric ducted & ductless HP vs. electric resistance	55%	55%	55%	55%

✓Technology continues to improve

- New generation systems can operate as low as -20°F (efficiently as low as -13°F)

Researched confirmed by others

- 2019 Dual Fuel Air-Source Heat Pump Monitoring Report [Michigan] – *Slipstream*
- British Columbia [Canada] Cold Climate Heat Pump Field Study – *RDH Building Science*
- Air-Source Heat Pumps in Cold Climates [Vermont] – *Steven Winter Associates, Inc*
- Cold Climate Air Source Heat Pump Building Electrification Study 2020-2021 – *Massachusetts Clean Energy Center*



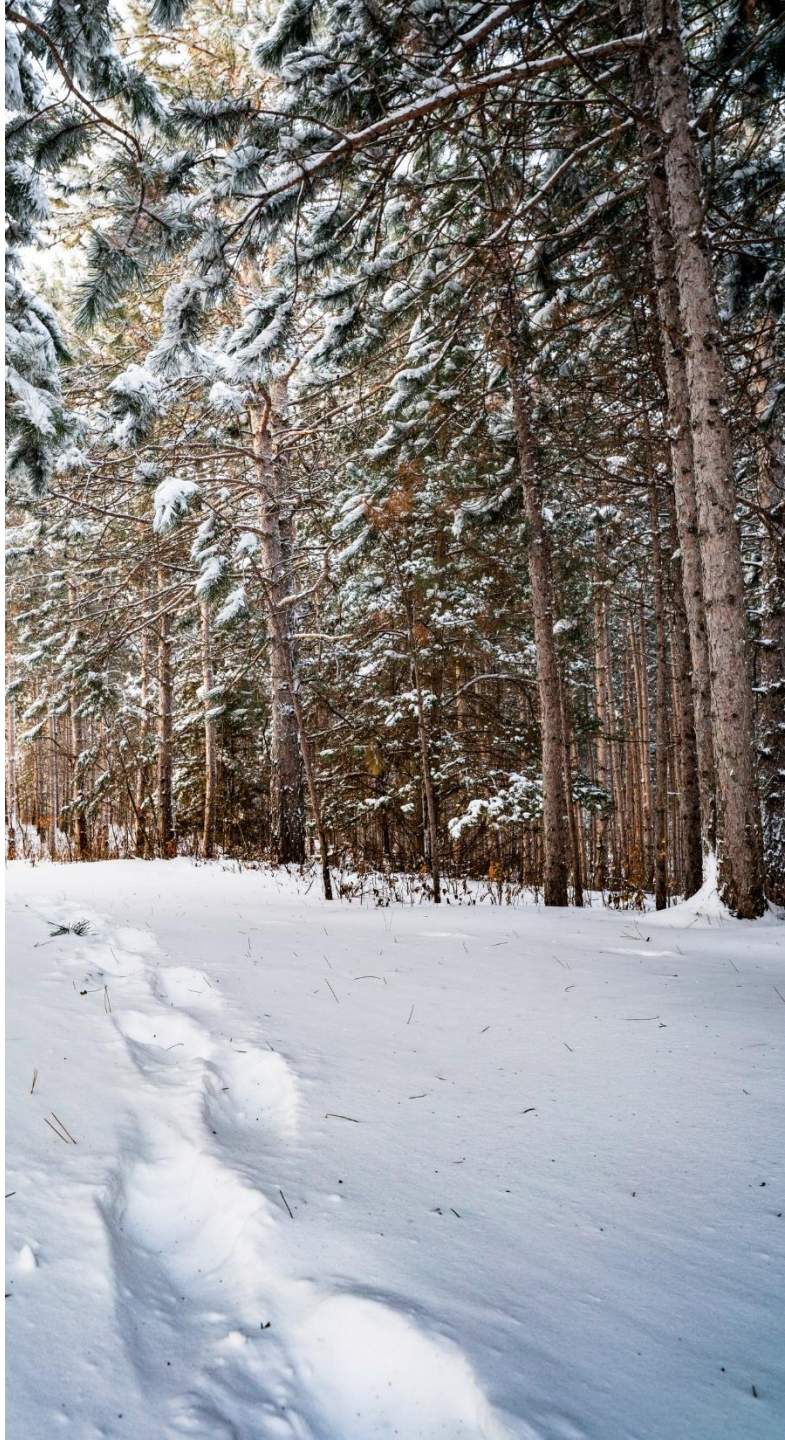
ASHP
air source heat pump collaborative

Really…in cold climates?

- Variable capacity advancements have expanded cold climate performance

- CEE field research studies observed systems delivering heat as cold as -25°F

- CEE field research is validated by other national-level field studies



What are the benefits and considerations of a cold climate ASHP?

ASHP Benefits – Big Picture

Heating and cooling all in one system

Fuel choice flexibility

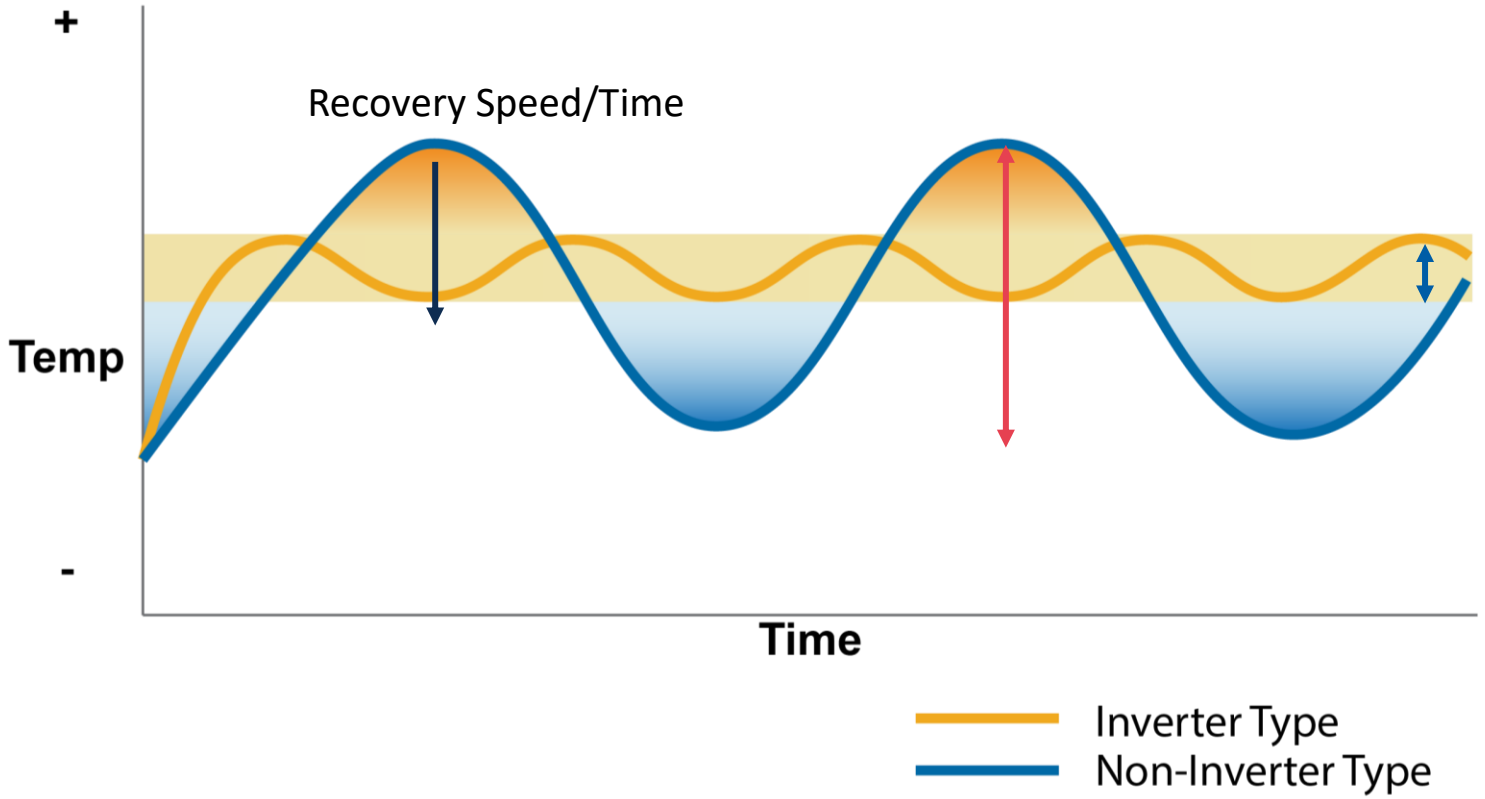
Improved comfort

Heating and cooling operational cost savings

Utility rebates

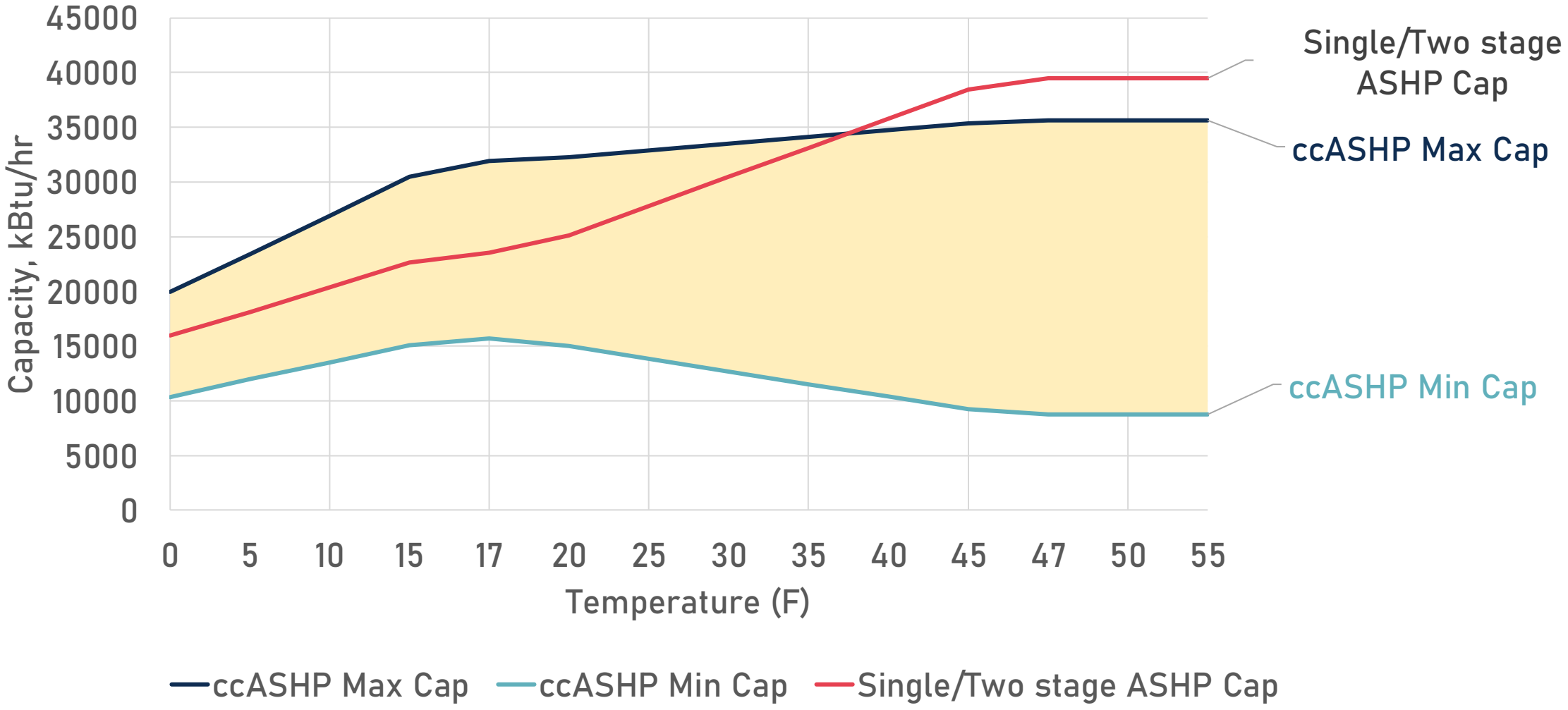
Reduced carbon emissions

How Modulation Helps - Control



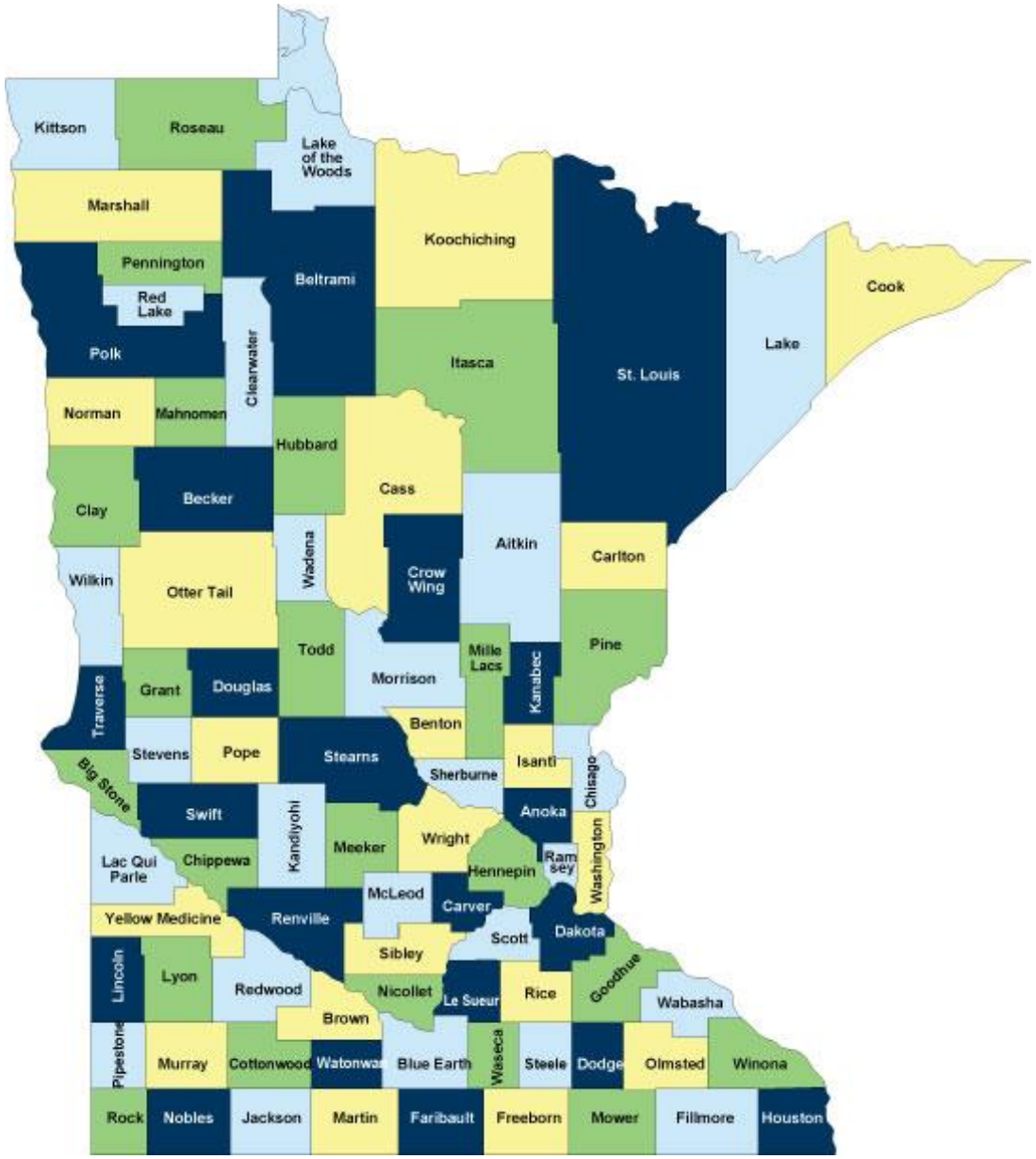
- More control
- Less waste
- Improved comfort

Variable capacity systems modulate to load for increased comfort and savings while offering higher capacity at lower temperatures



Let's think about a cold climate house and heat pump!

- Smaller home heating load of ~36,000 Btu/hr
- Winter design temperature of –9°F
- Looking for equipment with high capacity at low ambient temps and at least 9.5 HSPF
- Is selection as important as sizing?



https://neep.org/heating-electrification/ccashp-specification-product-list

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

Search Products | Consumer and Installer Resources | About ASHP Initiative | About NEE

Brand: American Stanc | AHRI, Model, Unit: AHRI, Model or Ur | Ducting Configuration: Singlezone Duc | Heating Capacity (Rated Btu/hr @47°F): 0 12000 48000 80000 | Heating Capacity (Max Btu/hr @5°F): 7000 44000 80000

Advanced Search - Sizing for Heating

‹ 1 › (25 Heat Pumps)

Grid View | List View

Download Product List

American Standard / Mitsubishi Electric
AHRI #: **204795658**
Singlezone Ducted, Centrally Ducted
23,900 Max Btu/hr @**5°F**
38,000 Rated Btu/hr @**47°F**
36,000 Rated Btu/hr @**95°F**
COP @5°F: **2.19**
HSPF: **9.5**
Outdoor Unit #: **ASUZA0361KA70B***
Indoor Unit #: **APVA0A0361AA70A**

VIEW DETAIL

American Standard / Mitsubishi Electric
AHRI #: **204795659**
Singlezone Ducted, Centrally Ducted
23,900 Max Btu/hr @**5°F**
38,000 Rated Btu/hr @**47°F**
36,000 Rated Btu/hr @**95°F**
COP @5°F: **2.19**
HSPF: **9.5**
Outdoor Unit #: **ASUZA0361KA70N***
Indoor Unit #: **APVA0A0361AA70A**

VIEW DETAIL

American Standard / Mitsubishi Electric
AHRI #: **204795632**
Singlezone Ducted, Centrally Ducted
17,700 Max Btu/hr @**5°F**
32,000 Rated Btu/hr @**47°F**
30,000 Rated Btu/hr @**95°F**
COP @5°F: **2.88**
HSPF: **10.8**
Outdoor Unit #: **ASUZA0301HA70B***
Indoor Unit #: **APEADA0301AA70A**

VIEW DETAIL

https://neep.org/heating-electrification/ccashp-specification-product-list

American Standard / Mitsubishi Electric

Singlezone Ducted, Centrally Ducted
AHRI Cert #: **204444398**
Outdoor Unit #: **ASUZH0361HA50NA**
Indoor Unit #: **APEADA0361AA70A**
Maximum Heating Capacity (Btu/hr) @5°F: **38,000**
Rated Heating Capacity (Btu/hr) @47°F: **38,000**
Rated Cooling Capacity (Btu/hr) @95°F: **33,000**

Advanced Data - Sizing for Heating

This tool is for preliminary product selection planning only. It is necessary to conduct full engineering capacity assessments that take line-length, multi-head impacts, and other factors into consideration. Use manufacturer's data and tools to finalize product sizing and selection determinations

State	Weather Station	Heating Design Temp. (°F)	Heating Design Load (Btu/hr)
MN	New Ulm Municipal	-9	36000

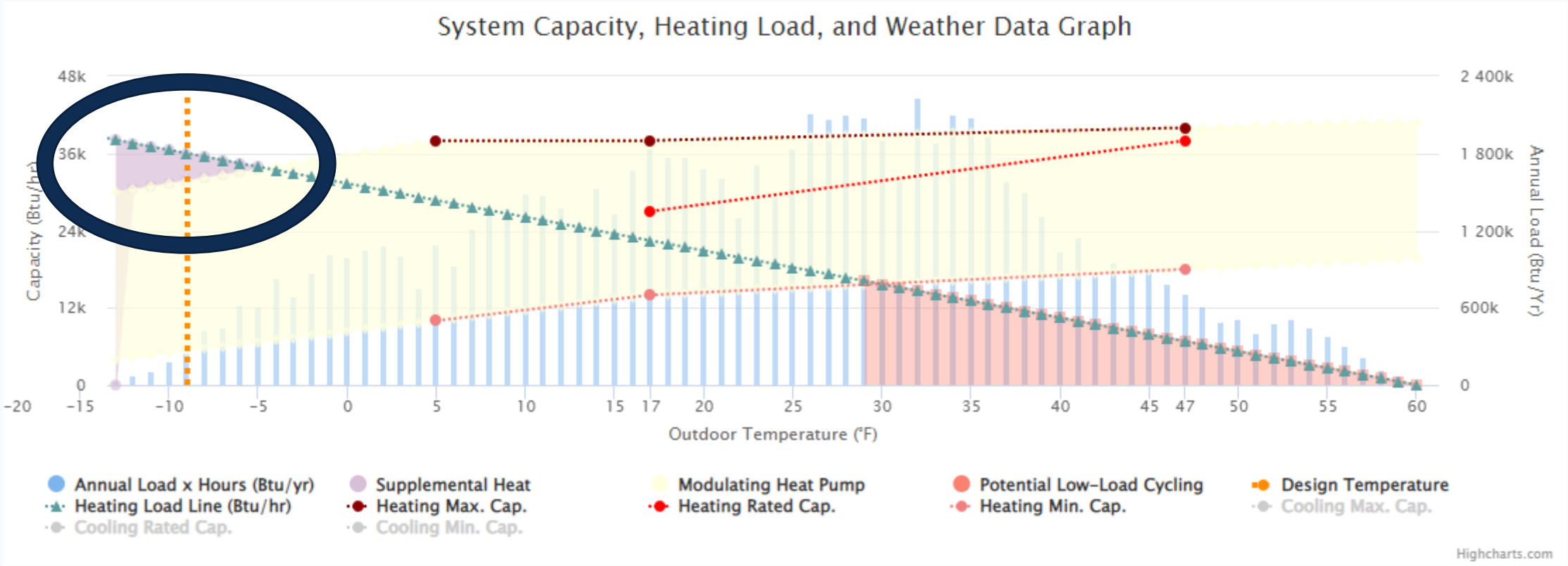
☐ Optional: Apply Lock-Out Temperature

☐ Optional: Manually Set Low Temperature Capacity Rating

Advanced Search - Sizing for Heating User Guide

Run Sizing for Heating Data

Graph Information



Product Sizing For Heating

Field Information

Capacity Balance Point (°F)	-5
Minimum Capacity Threshold (°F)	29
Maximum Capacity at Design Temp (Btu/hr)	31,778
Percent Design Load Served	88.3%
Annual Heating Load (MMBtu)	80.7
Percent Annual Heating Load Served	97.6%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	2.0
Hours Requiring Supplemental Heat	61
Percent Hours Requiring Supplemental Heat	1.0%
Percent Annual Load Modulating	57.7%
Percent Annual Load with Low-Load Cycling	37.3%

Size for heating or cooling?

New School

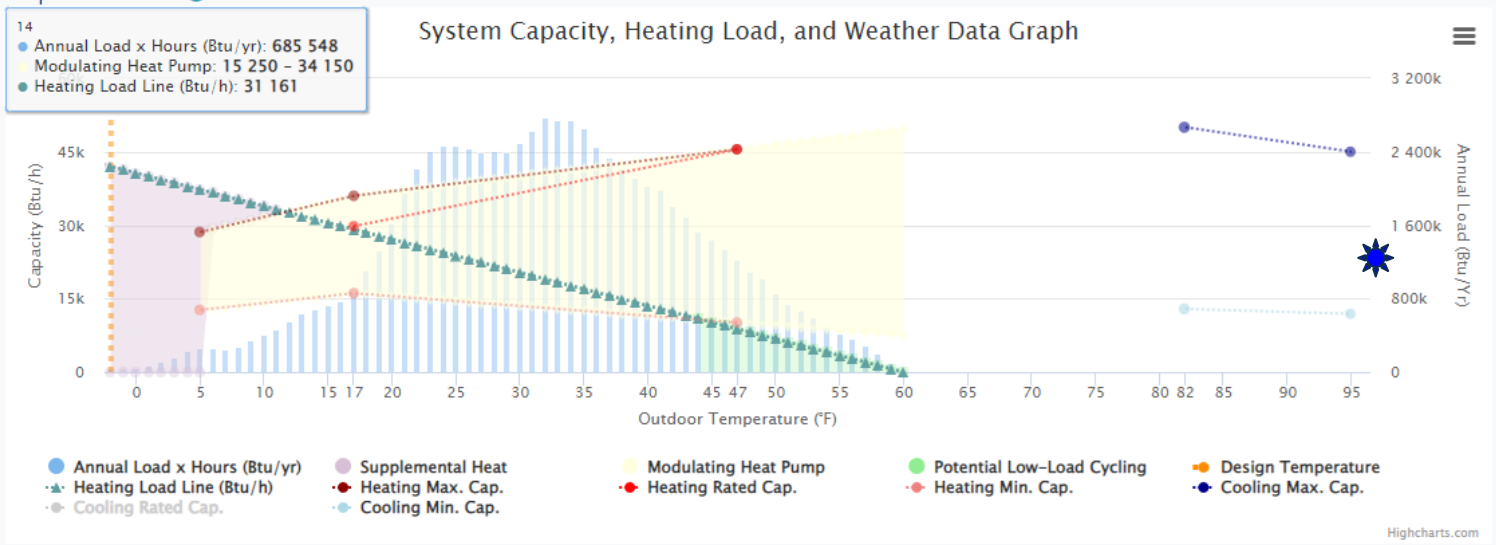
- Start by sizing to largest load.
- Using Manufacturer data for Max and Min capacities, check to see if the smaller load is between the Max and Min at the design temp.
- Likely OK to be within a half-ton!

Old School

- Size for cooling and then go up a half ton.
- Based on older single or two speed systems.
- Does not maximize heating potential of HPs.
- Does not account for modulation capabilities of VSHPs.

Example Daikin System

Graph Information



Product Sizing For Heating

The NEEP ccASHP database does not include max capacity data at the selected design condition for this product. Though ccASHPs will operate below 5°F, these calculation results assume 0 capacity below 5°F. Enter a known max capacity data point above for more accurate results.

Field Information

Capacity Balance Point (°F)	12
Minimum Capacity Threshold (°F)	44
Maximum Capacity at Design Temp (Btu/h)	No capacity at design Temperature
Percent Design Load Served	No capacity at design Temperature
Annual Heating Load (MMBtu)	77.6
Percent Annual Heating Load Served	96.5%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	2.7
Hours Requiring Supplemental Heat	83
Percent Hours Requiring Supplemental Heat	1.5%
Percent Annual Load Modulating	80.5%
Percent Annual Load with Low-Load Cycling	14.0%

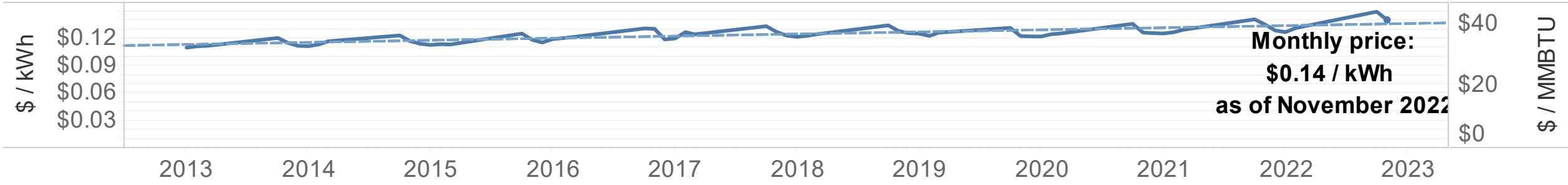
Minneapolis house

~52,200 Btu/hr heating load @ -11°F

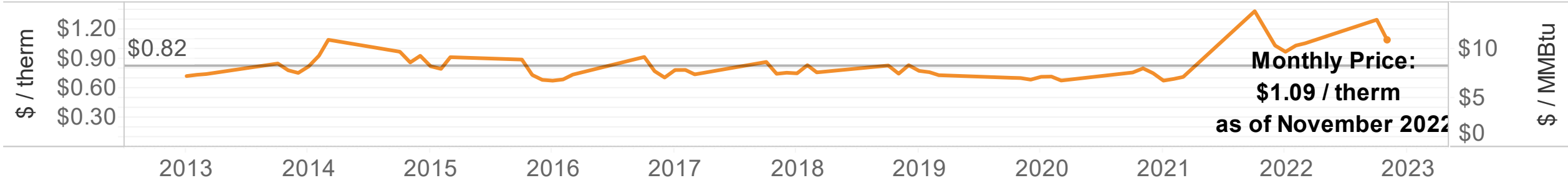
~26,000 Btu/hr cooling load @ 89°F

Maximize Energy Resilience and Price Protection with Hybrid Heat Pumps

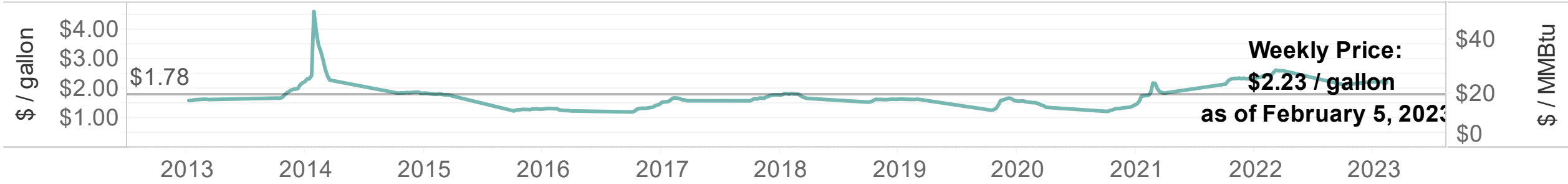
Minnesota Monthly Residential Electricity Price*



Minnesota Monthly Residential Natural Gas (Methane) Price



Minnesota Weekly Residential Propane Price



Note the wide fluctuations in propane and methane (natural gas) costs above. Electricity costs have predictable price fluctuations over time. Source: Energy Information Administration (US EIA). All charts exclude April-Sept. months. *Dual fuel or time of use rates may offer further discounts on ASHP operation. See local utility rates for details.

Sizing and Design Considerations

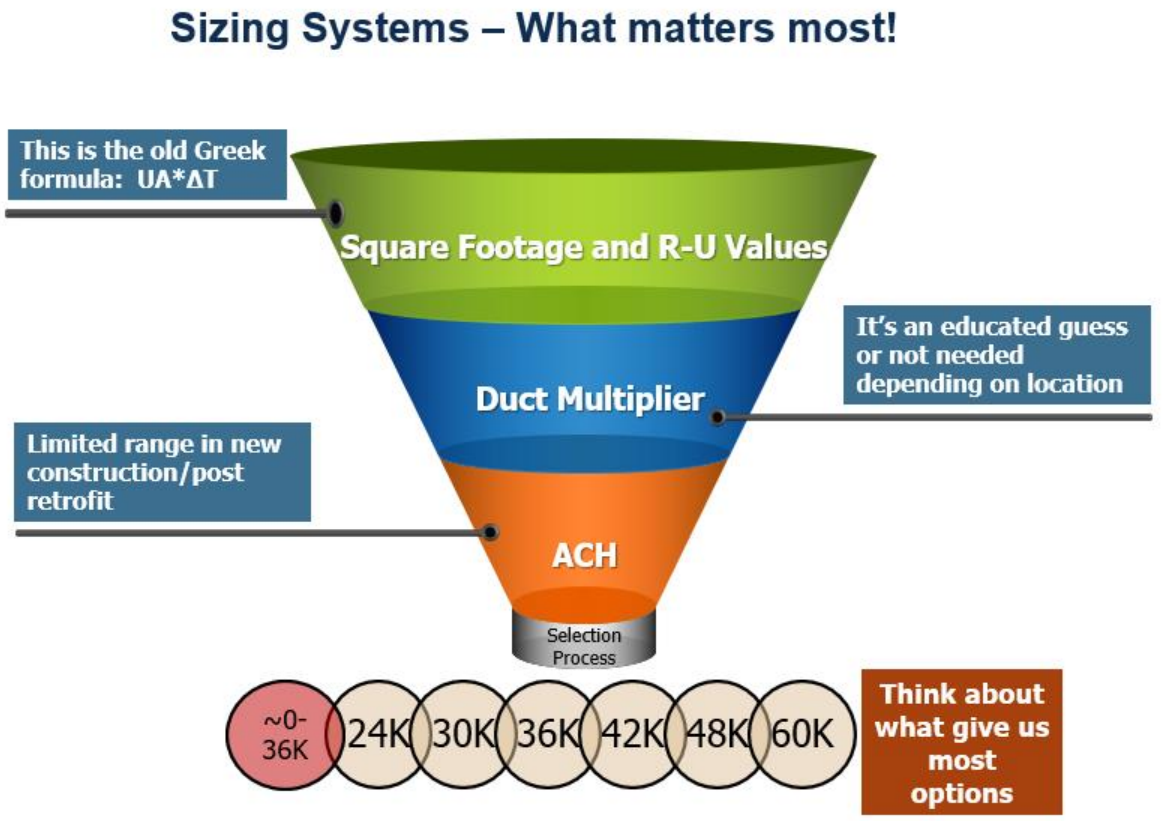
Definitions: Design Conditions

- Design Temperature is not the coldest day or hottest day of the year
- Winter Design Conditions: It only gets colder than this 1%-2.5% of the time
- Duluth:
  - Winter Design Condition is -20°F
  - Summer Design 83°F
- Minneapolis:
  - Winter -11° F
  - Summer 89° F

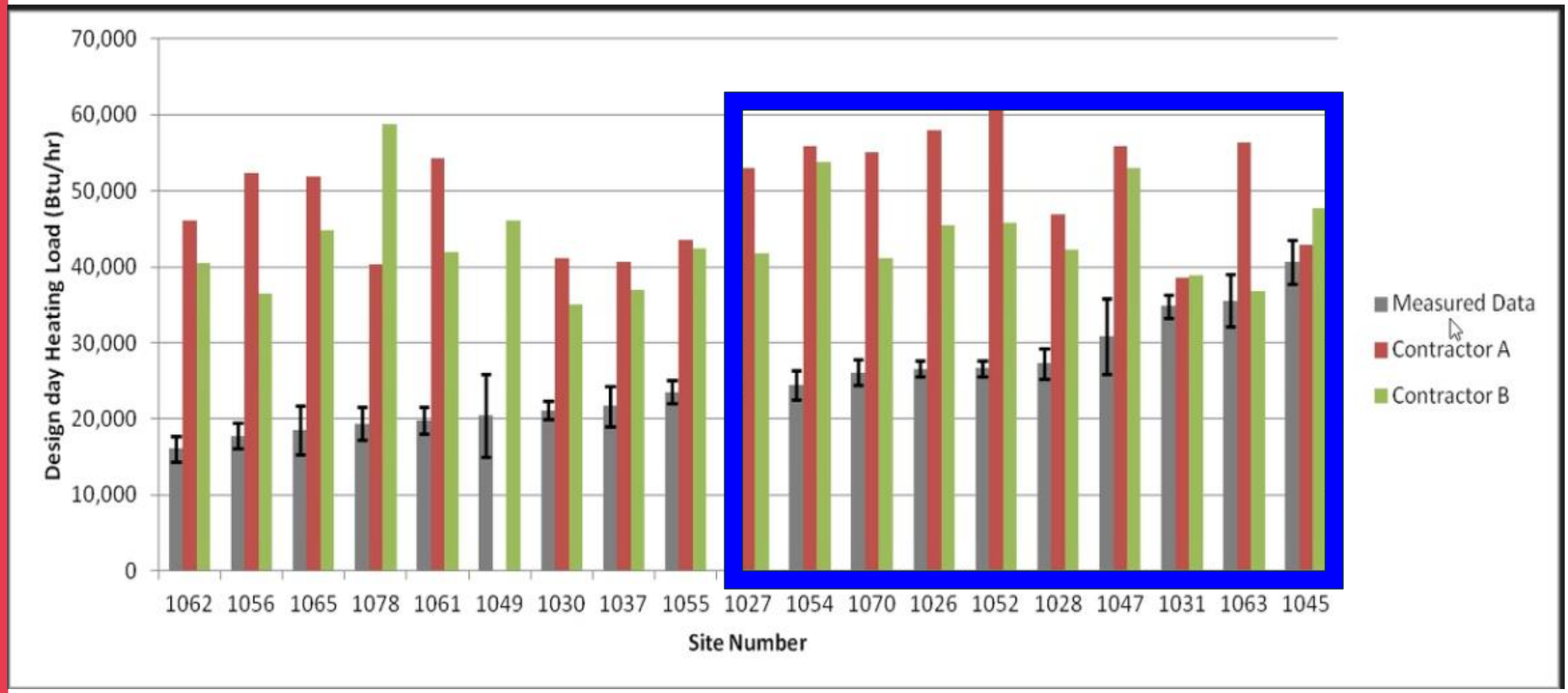
Sizing Considerations – Load Calculations

Level of heating load calculation time, effort and accuracy:

- Medium:
  - Comfort Consult + Block load
  - Energy Modeling
  - Existing equipment – with run time or utility bills
- High:
  - Room-by-room - Manual J or equivalent – detailed envelope information needed



Concerned that Manual J won't size large enough?



Sizing Guidance

Natural Resources Canada | Ressources naturelles Canada

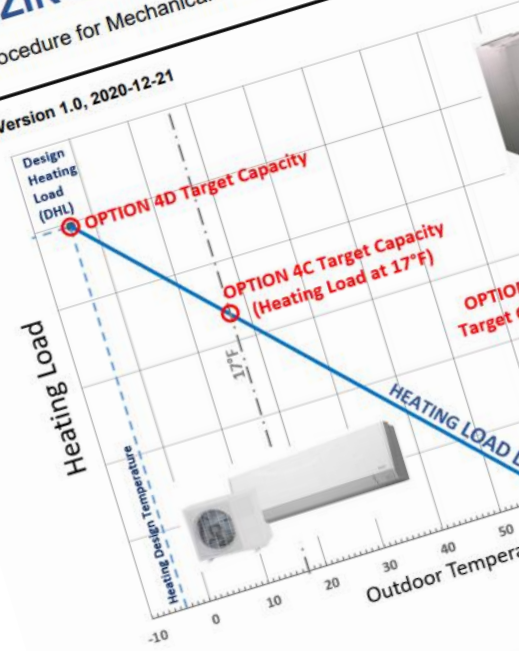
CanmetENERGY

Leadership in ecoInnovation

AIR-SOURCE HEAT PUMP SIZING AND SELECTION GUID

Procedure for Mechanical Designers and Renovation Contr

Version 1.0, 2020-12-21



rev 04/08/20

Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

A companion to NEEP's Guide to Installing Air-Source Heat Pumps in Cold Climates

Introduction

The use of air-source heat pumps (ASHPs) in cold climates is growing rapidly, but system sizing and selection practices have not always kept up with the wide range of applications commonly found in cold climates. System performance, comfort, and energy efficiency can be significantly impacted by poor sizing and system selection. The purpose of this guide is to assist installers in sizing and selecting ASHPs for residential cold climate applications, while maintaining high efficiency, performance, and customer satisfaction.

There are many types of equipment and a variety of common applications for ASHP installations in cold climates. Combinations of single and multi-zone, mini-split "ductless" and/or "compact-ducted" systems, and more conventional centrally ducted air-handler systems, may be installed in existing or new homes. When an ASHP is installed to reduce operating costs and/or emissions and existing heating equipment is left in place as a supplement, conventional approaches to sizing don't always apply, and controls can be important.

This guide is organized into four one-page application types so users can effectively match guidance to their specific installation. The applications are:

- Heating (or heating & cooling) displacement
- Full HVAC replacement
- Isolated zone
- New construction

Each category suggests the relevant information on sizing and equipment selection, system configurations, the optional use of pre-existing HVAC, and tips on key issues to look out for. Each application category includes a more detailed description of when that application would apply. Also, there is no cooling-only application type. In almost any circumstance, even if the client is initially interested in cooling, a cold-climate heat pump can provide cost-effective heating for at least some part of the winter. Thus all the applications considered assume intention to use the heat pump for at least some heating of the home.

For cold-climate applications, this guide is focused on products that appear on the Cold Climate Air Source Heat Pump (ccASHP) Specification. Therefore, variable-speed systems are assumed in this guidance. Cold climates may be considered to be International Energy Conservation Code (IECC) climate zone 4 and higher, though interest in cold-weather performance may extend into some of the hottest climates in the U.S. The following section provides additional general guidance on building efficiency, load calculations, and equipment selection that apply to all the application types.

Note: Heat pumps should always be installed by licensed, trained professionals. Always follow manufacturer's specifications and installation instructions, and all applicable building codes and regulations.

Ensure Building Efficiency

In existing buildings, always try to ensure that any building enclosure issues (insulation, air leaks/bypasses, existing duct disconnects/leaks, etc.) are addressed before installing new equipment. This reduces heating & cooling costs, improves comfort and heat pump performance, and reduces the size of equipment required. Enlist the help of a home performance professional if needed to diagnose these issues. Many electric and gas utility companies offer resources to support home performance upgrades. U.S. DOE's Home Performance with ENERGY STAR program also provides useful

Business & Industry | Communities & Governments | Partners & Investors | Researchers & Policymakers | Residents & Homeowners

Find a Program | Find A Contractor | About | Search NYSERDA | Change Language

Training Provider Resources

NYSERDA has developed training materials on Cold Climate Air Source Heat Pump Sizing and Design that are available for use in training programs.

- Course Curriculum Guide (PDF) – Topics for a training audience of technicians and installers
- Technical Sizing and Design Training Presentation Content (PPTX) – Training for industry professionals that follows the Course Curriculum Guide. Content suitable for heat pump manufacturers to train technicians and installers.
- Introductory Sizing and Design Training Presentation Content (PPTX) – Content suitable for heat pump sales and admin staff, utility program implementers, regulators and similar. (Note: This version does not fulfill the NYS Clean Heat sizing and design contractor's training requirements.)
- Guidance for Formatting Sizing and Design Training PowerPoint Slides (PDF) – Instructions for adding custom branding and formatting to the unbranded Sizing and Design Training PowerPoint slide files.

Training

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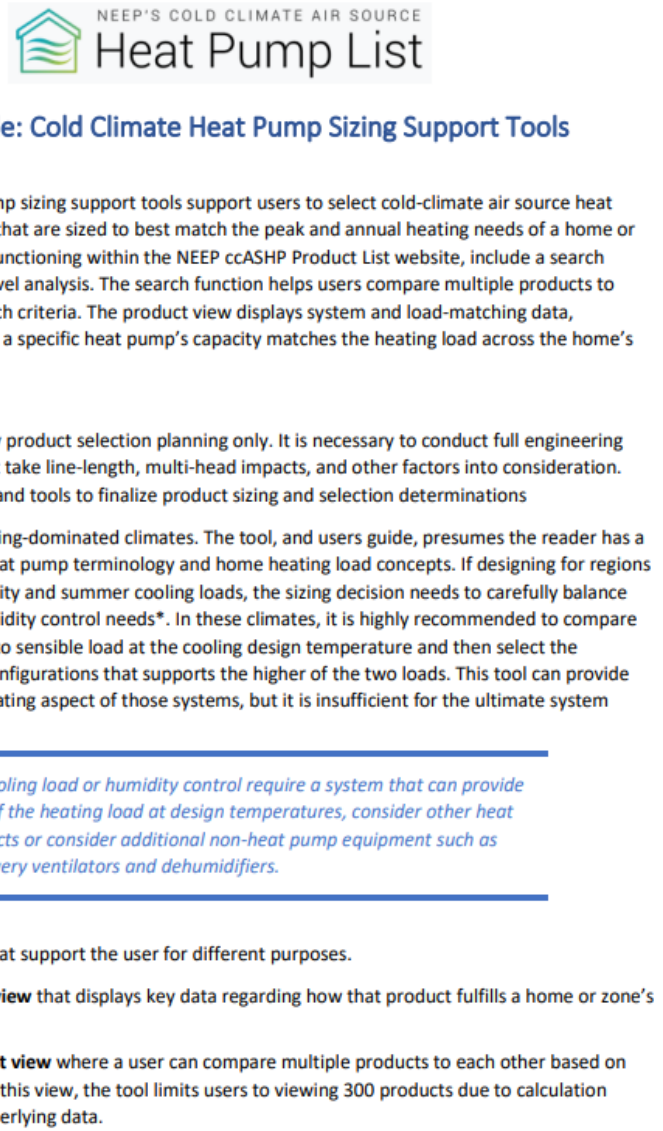
SHP heat pump collaborative

Sizing Guidance Resources

- NEEP Installer Resources – Guide to Sizing and Selecting Heat Pumps
- Air-Source Heat Pump Sizing And Selection Guide NRCan
- NY State Training Provider Resources
- NEEP Size for Heating Users Guide



NEEP'S COLD CLIMATE AIR SOURCE Heat Pump List

Users Guide: Cold Climate Heat Pump Sizing Support Tools

The cold climate heat pump sizing support tools support users to select cold-climate air source heat pump (ccASHP) products that are sized to best match the peak and annual heating needs of a home or heating zone. The tools, functioning within the NEEP ccASHP Product List website, include a search function and a product-level analysis. The search function helps users compare multiple products to each other based on search criteria. The product view displays system and load-matching data, providing a visual for how a specific heat pump's capacity matches the heating load across the home's winter temperatures.

Considerations

This tool is for preliminary product selection planning only. It is necessary to conduct full engineering capacity assessments that take line-length, multi-head impacts, and other factors into consideration. Use manufacturer's data and tools to finalize product sizing and selection determinations

This tool is for use in heating-dominated climates. The tool, and users guide, presumes the reader has a basic understanding of heat pump terminology and home heating load concepts. If designing for regions that also have high humidity and summer cooling loads, the sizing decision needs to carefully balance heating, cooling, and humidity control needs*. In these climates, it is highly recommended to compare sensible cooling capacity to sensible load at the cooling design temperature and then select the equipment and system configurations that supports the higher of the two loads. This tool can provide information about the heating aspect of those systems, but it is insufficient for the ultimate system selection.

> ** **Note:** If cooling load or humidity control require a system that can provide over 140% of the heating load at design temperatures, consider other heat pump products or consider additional non-heat pump equipment such as energy recovery ventilators and dehumidifiers.*

Views

This tool has two views that support the user for different purposes.

1. A single **product view** that displays key data regarding how that product fulfills a home or zone's heating load.
2. A **search result list view** where a user can compare multiple products to each other based on search criteria. In this view, the tool limits users to viewing 300 products due to calculation speeds of the underlying data.

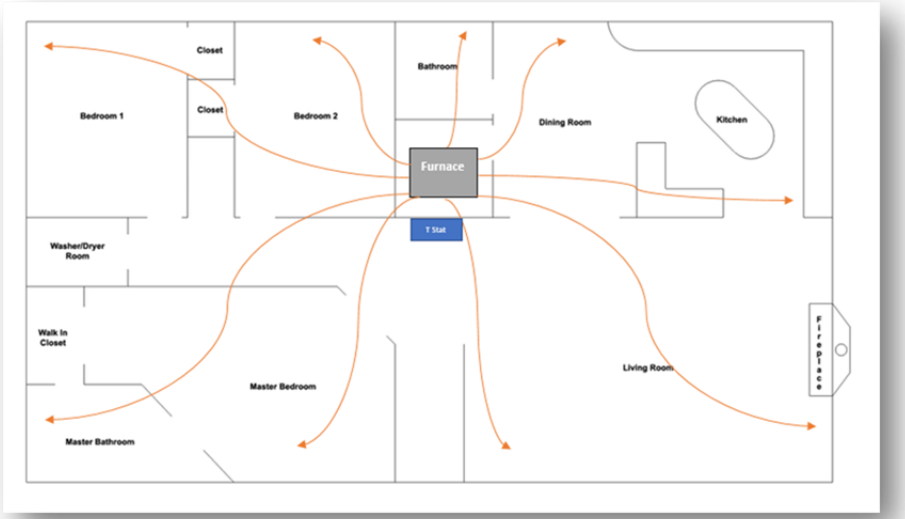
Goals of System Install

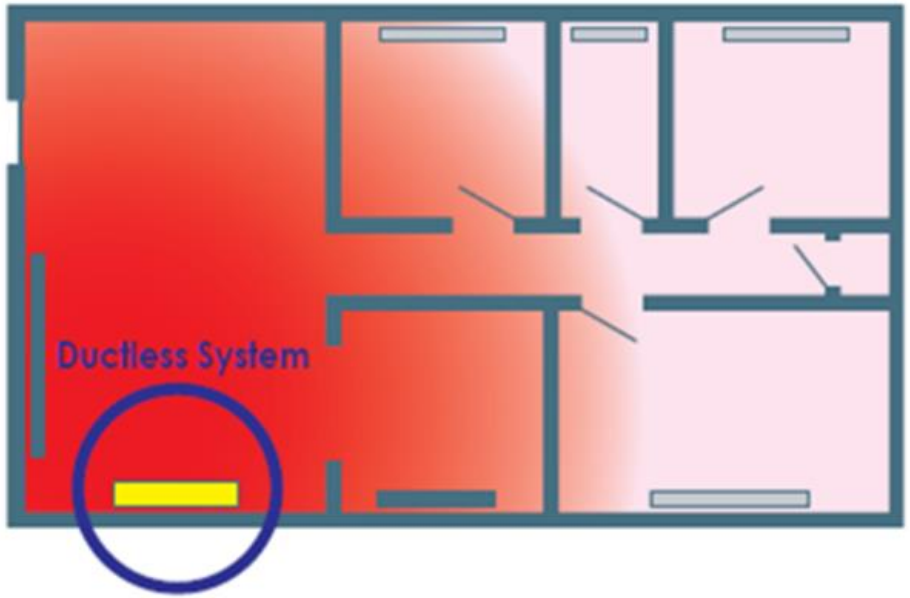
Displacement or Replacement?

Dual Fuel or All Electric?

Comfort complaints?

Bill complaints?





When to install the heat pump?

Is the homeowner considering or willing to weatherize

1. Yes, they are very interested in improved comfort, lower bills, and right sized mechanical systems
2. Not sure, but we should ask
3. No, this is an emergency replacement

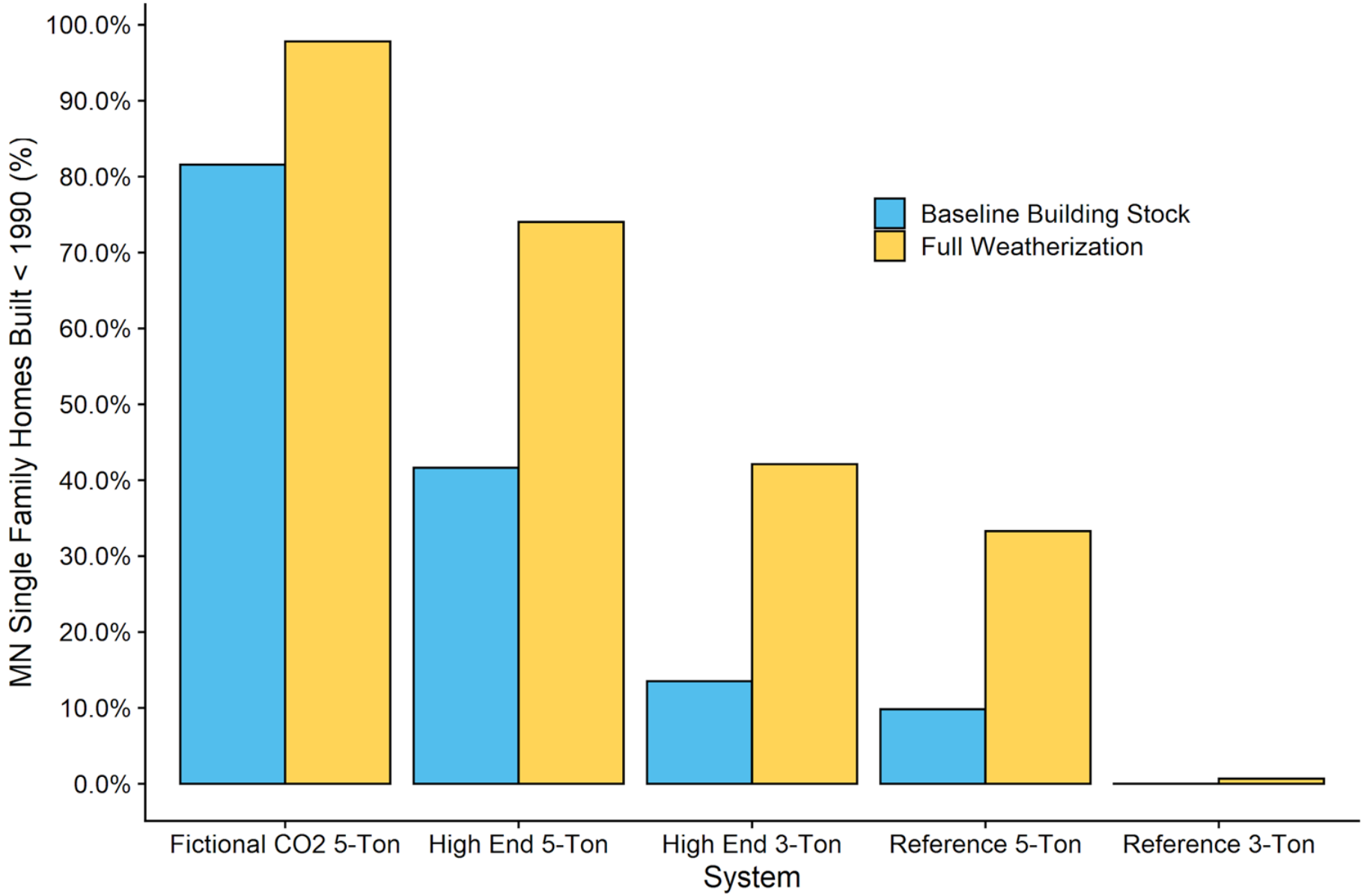
Prioritize timing

1. Likely best to install Heat Pump AFTER the Wx is completed
2. Can we introduce the homeowner to a contractor that does weatherization?
3. Can we install a heat pump that is flexible to future lower loads?

Contractors and programs -ask yourself how this approach would reflect on you to a homeowner!

Envelope Improvements Show Results

- Best system available could meet load on 75% of <1990 homes
- Even reference 5-ton system meets 33% of homes
- *25% peak load reduction*



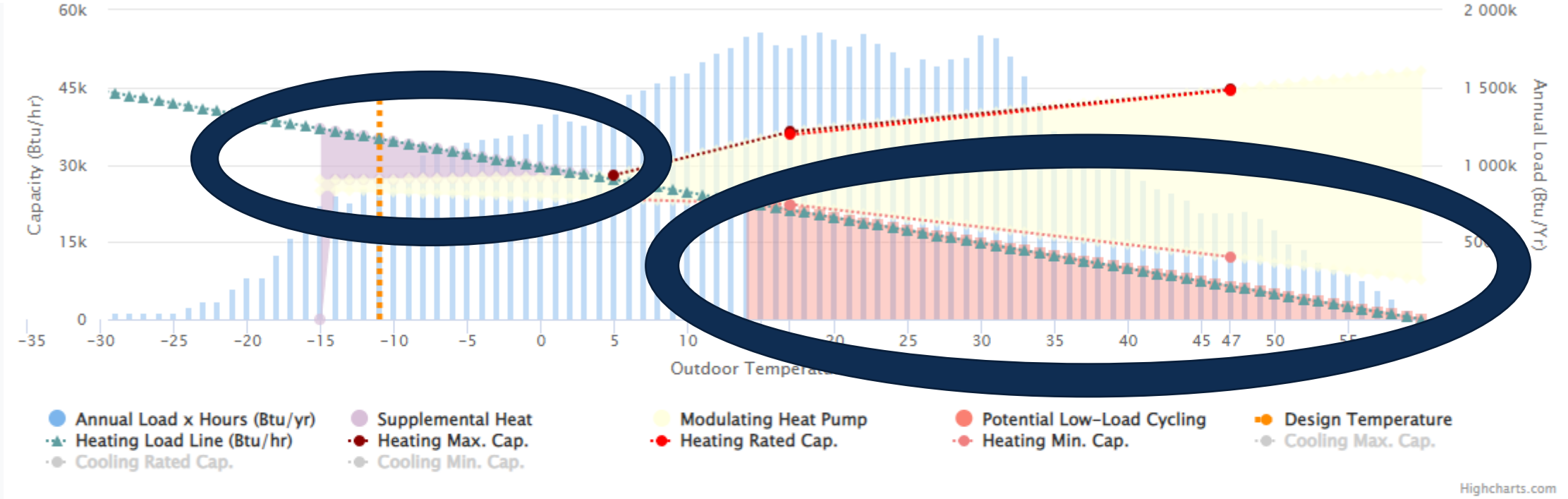
Opportunity

Reduce load –> right size equipment

“Eat your efficiency vegetables, followed by your equipment proteins, and then finish with renewable desserts.”

-Dan Wildenhaus

4-ton ccASHP system



Product Sizing For Heating

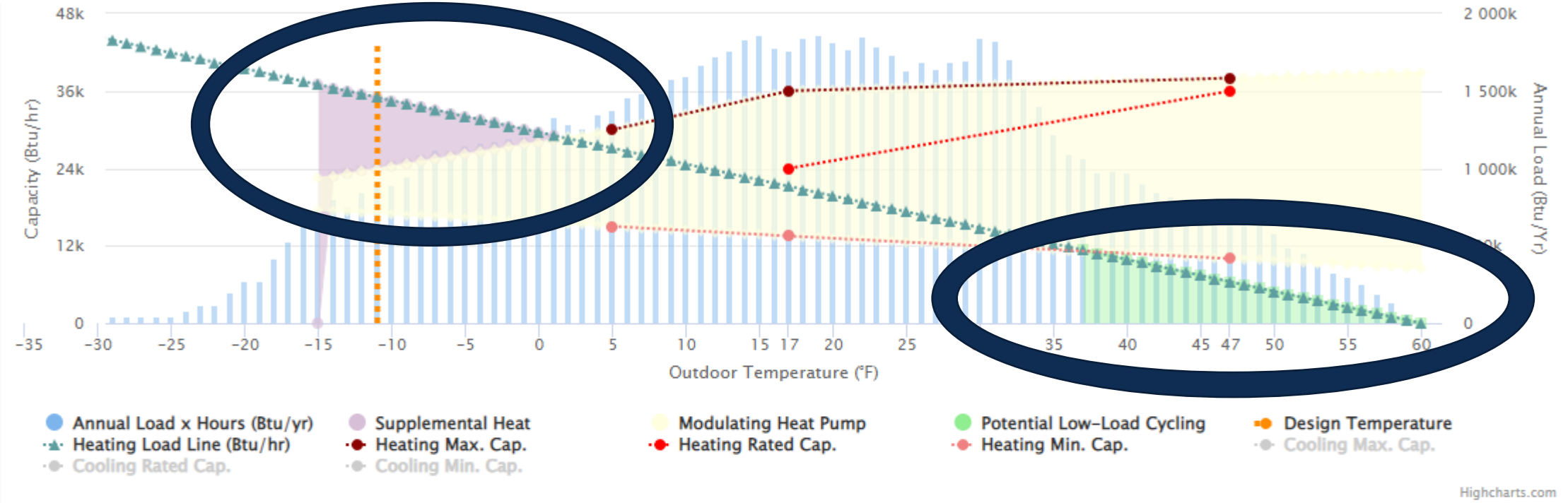
Field Information

Capacity Balance Point (°F)	3
Minimum Capacity Threshold (°F)	14
Maximum Capacity at Design Temp (Btu/hr)	27,200
Percent Design Load Served	77.7%
Annual Heating Load (MMBtu)	91.7
Percent Annual Heating Load Served	79.2%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	19.1
Hours Requiring Supplemental Heat	664
Percent Hours Requiring Supplemental Heat	10.5%
Percent Annual Load Modulating	21.4%
Percent Annual Load with Low-Load Cycling	55.8%

3.5-ton ccASHP system



Product Sizing For Heating

Field Information

Capacity Balance Point (°F)	2
Minimum Capacity Threshold (°F)	37
Maximum Capacity at Design Temp (Btu/hr)	24,000
Percent Design Load Served	68.6%
Annual Heating Load (MMBtu)	91.7
Percent Annual Heating Load Served	81.4%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	17.0
Hours Requiring Supplemental Heat	619
Percent Hours Requiring Supplemental Heat	9.8%
Percent Annual Load Modulating	66.2%
Percent Annual Load with Low-Load Cycling	14.1%

Installation Considerations

Installation Considerations

- Control and operation
- Integration with backup
- Sizing

More installation considerations

- Compressor placement
- Line set installation
- Condensate management
- Right charged refrigerant

Installation Common Failures/Mistakes

- Two most common mistakes:
  - Outdoor unit not secured and/or elevated
  - Lack of adequate line set protection

- Other Mistakes:
  - Poor homeowner education
  - Inadequate clearances
  - Aesthetically unappealing installations
  - Installed heads not level for DHPs
  - Condensate or line set blocks filter door for ASHPs

Poorly Installed Outdoor Units

Installing Line Set

- Insulation disturbed to install refrigerant lines must be returned to original (or better) condition

Unique requirements

- High wind zones, securing compressors may be required by codes, permitting offices, and programs.

Unique requirements

- High wind zones, baffles may be a recommended practice, depending on manufacturers.

Homeowner Education

WELL-INSTALLED OUTDOOR + INDOOR UNITS = SATISFIED HOMEOWNER

- Happy, well-educated homeowners are the best salespeople
- Satisfied customers tell their family, friends and neighbors

The Best Practices Installation Guide

Installation Guide

Air Source Heat Pumps Best Practices

Companion Guide to the Minnesota ASHP Collaborative's Design Guide

Introduction

High quality installation of air source heat pumps (ASHPs) improves system performance and efficiency, optimizing heating down to colder temperatures. This performance improvement can ensure customer satisfaction and comfort, which in turn reduces callbacks, generates referrals, and increases sales. This guide outlines the best practices for all ASHP installations, as well as guidance on homeowner education to help keep customers happy and ASHPs efficient in cold climates. For guidance on equipment selection, system sizing, and proper design, see our ASHP Design Guide, which provides information on

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Installation Requirements and Best Practices

Line Set

- Installers should follow the manufacturer's instructions for minimum and maximum line set length and height change.
- Line set must meet the manufacturer's specification for the indoor unit — adaptations to the outdoor portion can be made if necessary.
- Insulation must cover the entire line set length (i.e., both pipes) to avoid condensation and energy loss. Once insulated, the outdoor portion of the line set should be protected with a rigid cover to avoid insulation damage. Note: It is important to also insulate flare nuts to stop liquid or frost from developing under the flare nut, which can cause cracks.
- UV-resistant tape or other mechanical protection should be installed as needed to protect any remaining exposed insulation. UV-protected insulation products meet this requirement.
- Line set penetration through the building enclosure should be protected from rodents (e.g., with a PVC sleeve and cap drilled to the size of the refrigerant lines, metal-wool stuffing, or similar).
- All penetrations through the shell of the home should be sealed with insulating sealant/spray foam. Any aspects of the insulation disturbed by installed line set should be returned to proper condition.
- Prevent partial kinks in line sets. Partial kinks can cause significant impact to heat pu and performance in cold temperatures. Kinks typically occur in line sets that are grea to 7/8" in diameter. Follow these steps to check for partial kinks:
  1. Remove line set covers.
  2. Set the machine to its most powerful mode so it heats at full capacity.
  3. Feel along the entire length of the line set for hot spots, which indicate where any partial kinks are located.

REQUIRED TOOLS: Ratchet flaring tool, programmable refrigerant charging scale, torqu gauge and hose set, vacuum pump (not pictured), flare gauge (not pictured)

Refrigerant Tubing

- Create new flare fittings using a ratchet flaring tool and measurement gauge appropr refrigerant and in accordance with the manufacturer's instructions. Apply refrigerant each flare.
- Connect tubing with the appropriate nuts (supplied by manufacturer) and tighten to th manufacturer's torque specifications.
- Once used, **DO NOT REUSE** manufacturer-provided tubing flares and fittings. **DO NOT** flare fittings that were not provided by the manufacturer.
- Any brazed connections should be completed with dry nitrogen to prevent oxidation.

Refrigerant Charge

- Pressure test the line set using dry nitrogen and triple vacuum pump evacuation per manufacturer's instructions.
- The vacuum should be held at 500 microns or less for a minimum of 15 minutes in each of the three vacuum cycles, and then valved off to check for pressure changes that indicate contamination or leaks. Each evacuation should be alternated with nitrogen under pressure.
- Test refrigerant lines only at pressures lower than the rating of service valves (typically 500–600 PSI, or per manufacturer's specifications).
- Refrigerant charge should be adjusted **ONLY IF NECESSARY** — many installations do not require adjustment from pre-charge levels with standard line set.
- Carefully recommer refrigeran any nonst Consult th installatio software refrigeran follow proper procedures for weighing and recovering refrigerants. Always use a scale when adding or removing refrigerant.

Condensate Drain

- The drain should slope downhill. It can be routed with line set and run to a suitable termination point — away from crawl spaces, walkways, and outdoor equipment.
- Alternately, use an external condensate pump when required.
- Ductless systems may have limited horizontal or vertical lift built in. Do not manufacturer's specifications vertical lift before a continuou

Outdoor Unit Installation

- Outdoor units should be placed to allow for free air flow. Follow manufacturer's guidance on clearance from obstructions, including walls, overhangs, protrusions, and other features. Ensure that outdoor units do not interfere with windows or doors.
  > Install outdoor units in a location protected from the wind if possible. Wind chill can affect heat pump performance, and facing into the wind can push freezing rain or snow into the system. If this cannot be avoided, install a wind baffle from the manufacturer to protect the system.
- The customer should always approve the location of outdoor units. The units should be located in inconspicuous places for aesthetic and noise considerations (e.g., behind the building).
  > Locate outdoor units away from bedrooms and other quiet spaces.
- Follow manufacturer-allowed clearances when placing multiple units. Multiple units should not be installed above each other or with outdoor fan outlet flow pointing directly at another unit (except when explicitly recommended by manufacturer).
- Ensure adequate clearance above historical average maximum snow depth, typically 14" in Minnesota. Secure outdoor units to a pad, risers, or the surface they sit on using a factory-approved stand and bolts or adhesive. Ensure that any ground-mounted unit is on soil that is well drained and will not heave with frost. The outdoor unit should be level both side-to-side and front-to-back. Best practice: use wall brackets designed for attachment to foundation wall, when ground clearance allows.
  > Installations can also use wall mounts or brackets designed for attachment to foundation wall. In these cases, use double-ended vibration absorbers to prevent both noise transfer through the wall and premature failure of the attachments.


Proper pl
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- Avoid proximity to walkways or other areas where re-freezing defrost meltwater might cause a slip-and-fall hazard.
- When possible, avoid installing outdoor units directly under any drip line from the roof or other overhang that would subject them to falling snowmelt, ice, or concentrated rain runoff.
  > When this is unavoidable and a functioning gutter is not present, outdoor units should be installed with drip caps or shields approved by the manufacturer.
- Install surge suppressors at service disconnect to protect sensitive electronics. Alternatively, suppressors may be installed at circuit breaker box if device is approved for such application. Follow manufacturer's instructions and all applicable codes and standards.
- Drain pan heaters are strongly recommended for cold-climate ASHPs that operate below 32 degrees Fahrenheit. These are not generally needed for non-cold-climate systems in situations where meltwater clearance and protection from precipitation are adequate.


Proper outdoor placement, showcasing a drip cap/snow shield.

Homeowner Education

- Provide a copy of the manufacturer's owner manual to the homeowner
- Take the time to demonstrate basic controls and operations to homeowners. Review maintenance schedule and other activities with them.

Additional Resources

- U.S. Department of Energy Building America Solution Center (HVAC-Heating Equipment) — basc.pnnl.gov
- ENERGY STAR®-Verified HVAC Installation (ESVI) Program energystar.gov/index.cfm?c=hvac_install.hvac_install_index
- ACCA Standard 5 (ANSI/ACCA 5 QI-2015); HVAC Quality Installation Specification acca.org/standards/quality

Acknowledgements: Existing best practices documents provided important content to this guide. We'd like to recognize and thank Northeast Energy Efficiency Partnership and Northwest Energy Efficiency Alliance for their contributions.

https://www.mnashp.org/guides

Benefits and Considerations by Application Type

ASHP Application Types

Existing HVAC	ASHP Options	Considerations	Market Size
AC replacement – with ductwork	Ducted ASHP	Sizing, energy costs, product cost, change over temperature	1,200,000 homes
AC replacement – without ductwork	ccDHP	Sizing, comfort needs, product cost	320,000 homes
Electric baseboard	ccDHP	Sizing, home configuration, number of heads	270,000 homes
Propane furnace	Ducted dual-fuel ccASHP	Sizing and change over temperature	250,000 homes
Electric furnace	Ducted ccASHP	Sizing and electric plenum backup	87,000 homes

How often do you replace equipment on failure?

How often do you replace both furnace and AC?

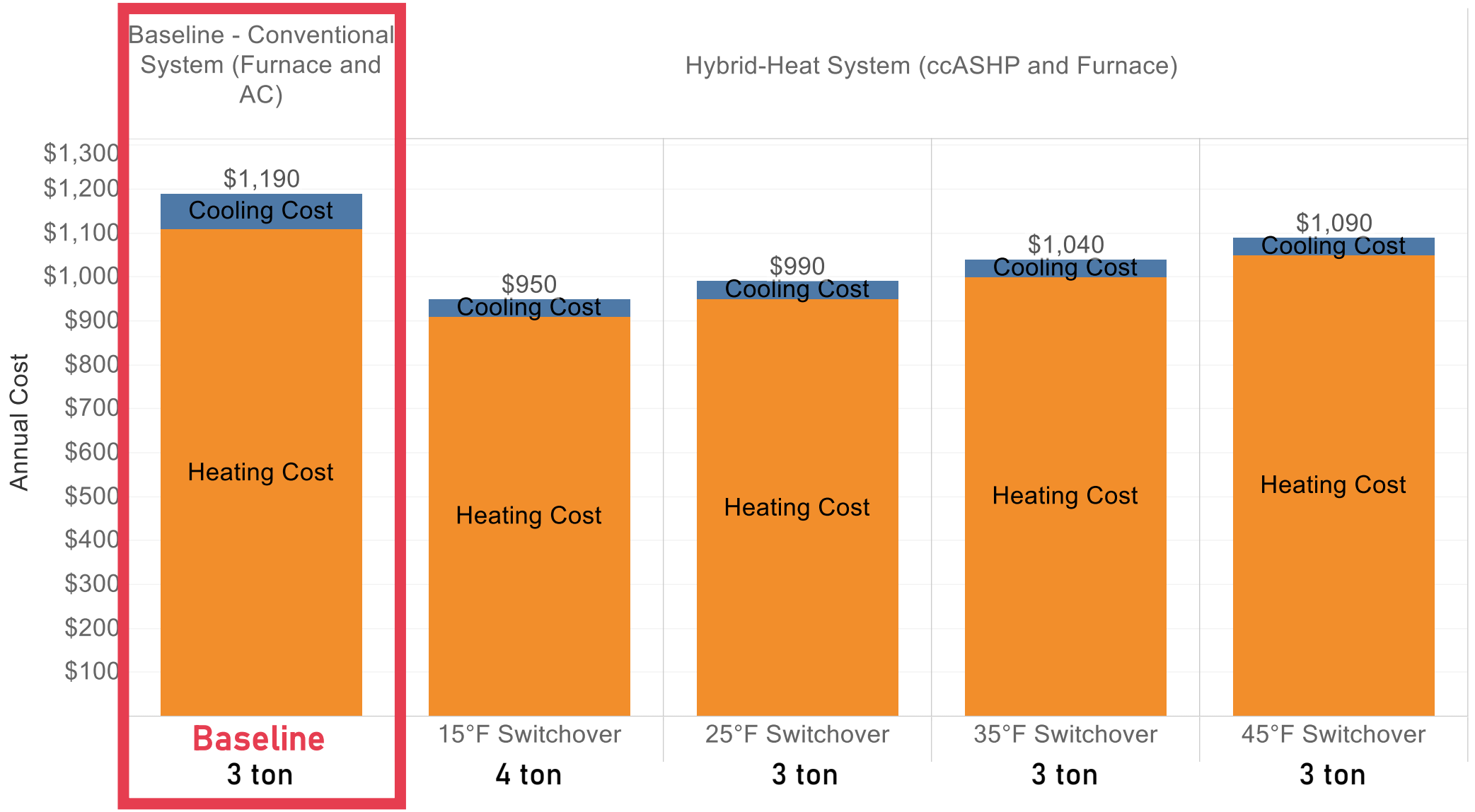
Scenario	Average frequency
“How often do you replace an AC when it has failed?”	67% of the time
“When an AC has failed, how often do you also replace the furnace?”	50% of the time
“When a furnace has failed, how often do you also replace the AC?”	51% of the time

Ducted, dual fuel cold-climate heat pump to displace furnace and replace AC

Benefits

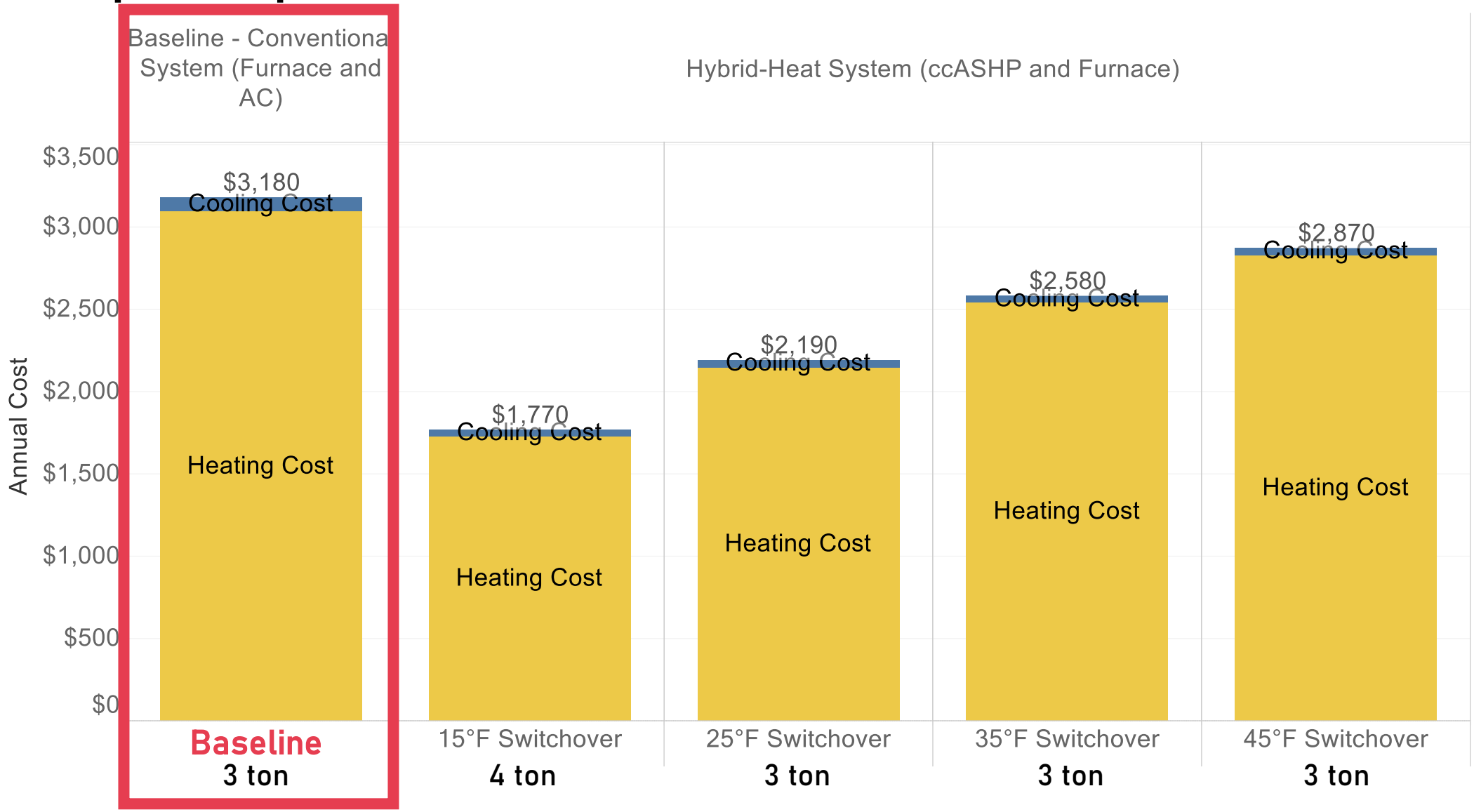
- Ideal for AC replacement
- May have older furnace
- Resilience and future proof
- Homeowner education is an opportunity

Operating costs: dual-fuel ccASHP with natural gas backup compared with a furnace and AC



Average NEEP QPL heat pump; Dual fuel electric rate: 6¢/kWh; Natural gas: $82/dtherm; Weather station: Duluth, MN

Operating costs: dual-fuel ccASHP with propane backup compared with a furnace and AC



Average NEEP QPL heat pump; Dual fuel electric rate: 6¢/kWh; Propane: $2.10 / gallon; Weather station: Duluth, MN

Ducted AC and Furnace considerations

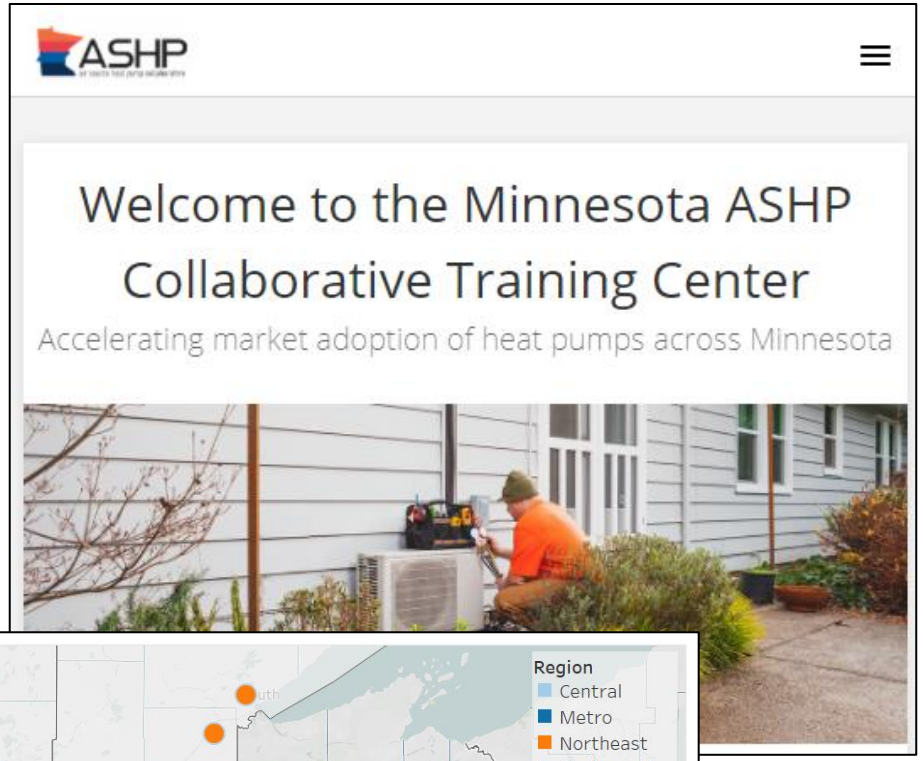
- Sizing – heating or cooling load
  - **Size up to 115% of higher load**
  - Reference max capacity at 17°F
- Compressor Locations
  - City/jurisdiction requirements
  - Local HOA restrictions
  - Placement away from operable windows
- Controls – thermostat setpoints
  - Use **economic switchover temperature**
  - Low setbacks for thermostat
- Homeowner Education
  - No need to run constant fan
  - Temperature controls training
  - Delivered air temperature expectations

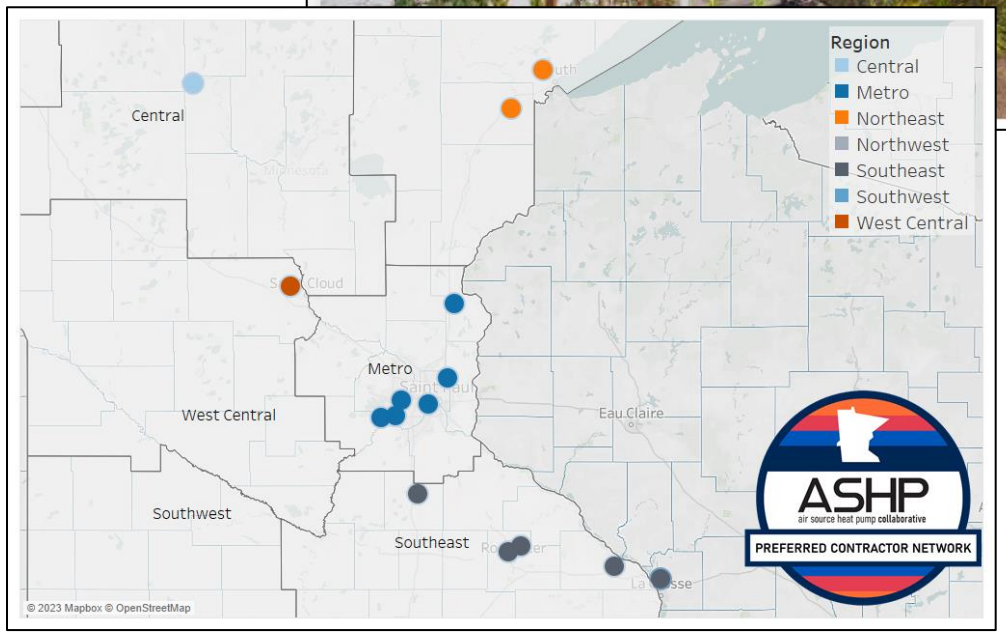
Consider ductwork, weatherization, along with cooling and heating load when sizing retrofits

Where can we find more resources on ASHPs?

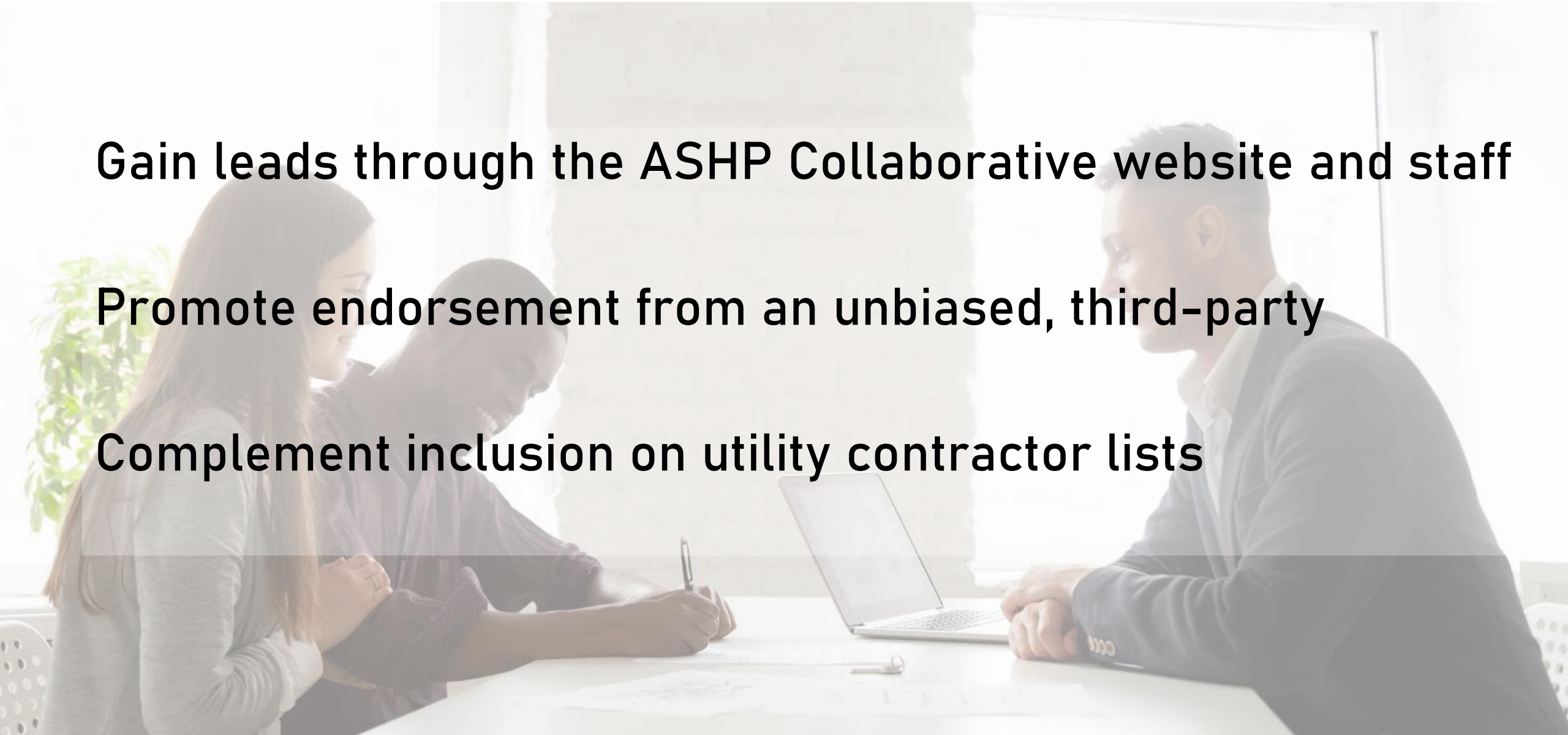
MN ASHP Collaborative Contractor Resources

- Preferred Contractor Network
- Incentives and financing
- Cost of heat comparison tool
- In person training
- Free on-demand training modules
- Best practices guide
- Manufacturer promotions





ASHP Preferred Contractor Network



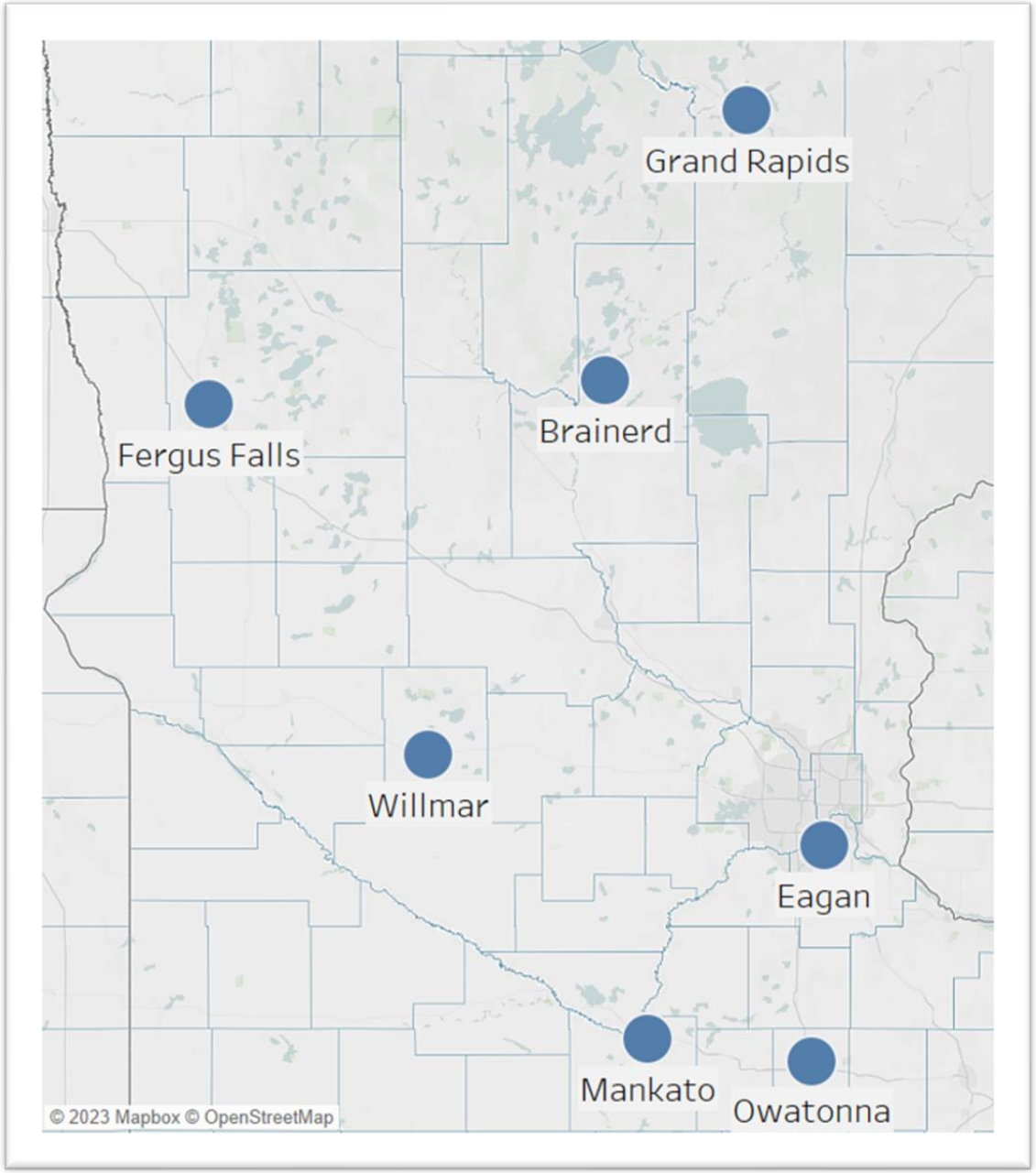
Gain leads through the ASHP Collaborative website and staff

Promote endorsement from an unbiased, third-party

Complement inclusion on utility contractor lists

Upcoming Events

- ASHP Fundamentals Course – April 24-28
- 6 MN cities throughout the week
- Free 2-hour course
- Free hot breakfast
- Earn CEUs for NATE, BPI, MN Department of Labor and Industry
- Satisfy pre-requisite coursework for Preferred Contractor Network
- Registration is open and required
    - Owatonna: 4/24
    - Mankato: 4/24
    - Willmar: 4/25
    - Fergus Falls: 4/26
    - Brainerd: 4/27
    - Grand Rapids: 4/28



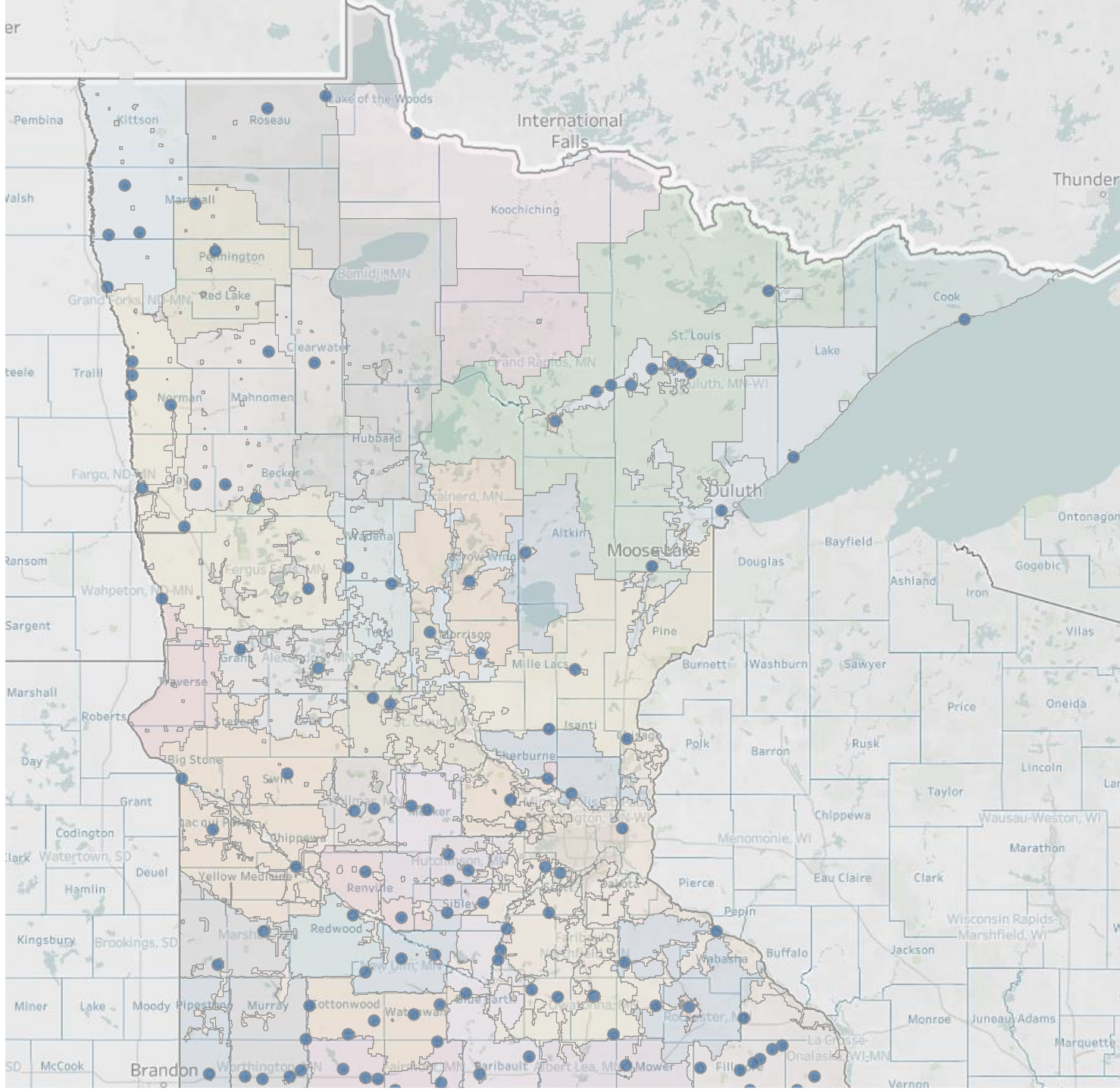
CONTINUING EDUCATION

DEPARTMENT OF LABOR AND INDUSTRY

Incentives and Financing

- IRA tax credit equipment specifications
- State rebates from IRA [coming soon]*
- Loan options beyond in-house financing products
- Utility rebates
  - Interactive map
  - Downloadable database

*https://mn.gov/commerce/energy/federal-rebates/



Monthly Contractor Newsletter

- Limited time manufacturer and utility rebate opportunities
- Updates on statewide Inflation Reduction Act rebate programs
- Event and conference opportunities
- New CEE ASHP research
- New tools, case studies, and resources

https://www.mnashp.org/contractor/#newsletter

MN ASHP Collaborative Homeowner Resources

- Financing information
- FAQ
- Case studies across MN
- Buying guides
- Product finders
- News articles
- Blog
- Contractor lookup through Preferred Contractor Network

Next Steps for Contractors

Practice installations at employee homes to gain experience with the technology

Attend ongoing distributor and manufacturer trainings

Apply to become a preferred contractor

Leverage and stack financial incentives and lending products

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ASHP
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