Getting the Most out of Air Source Heat Pumps in our Cold Climate

Air Source Heat Pump Contractor Training

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CEUs available for today's training

- North American Technician Excellence (NATE)
- MN ASHP Collaborative Preferred Contractor Network

Please make sure to sign in and provide your ID number to receive credit.

Quick polls

- How many installed heat pumps for customers in the last year?
- How many of these were ducted, variable-capacity heat pumps?
- How many work in areas with customers who heat with propane?
- How many install heat pumps on dual fuel electric circuits?
- How many have heat pumps in their own homes?

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Discussion goals

- ASHP potential and field research
- Level setting terminology
- Homeowner support & education
- ASHP application types
- Sizing and design considerations
- Equipment selection
- Controls strategies
- Installation considerations

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

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 Overview

- Launched in 2019
- Investor-owned, cooperative, and municipal utilities contribute funding
- Mission to make air source heat pumps the first choice for consumers when cooling and heating their homes
- Supportive of dual fuel approaches

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Minnesota's Efficient Technology Accelerator is a partnership funded by the state's investor-owned utilities (IOUs), administered by the Minnesota Department of Commerce, Division of Energy Resources (DER), and implemented by Center for Energy and Environment (CEE).

ASHP Potential in MN

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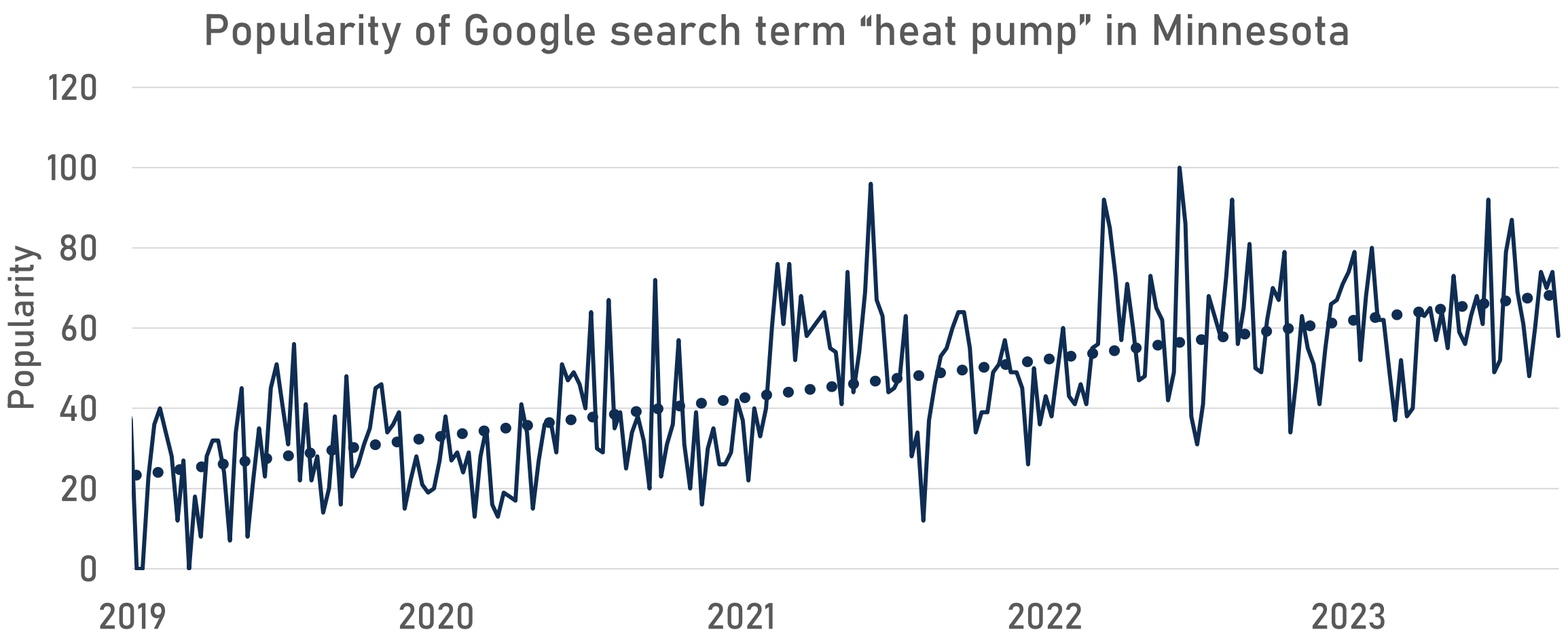
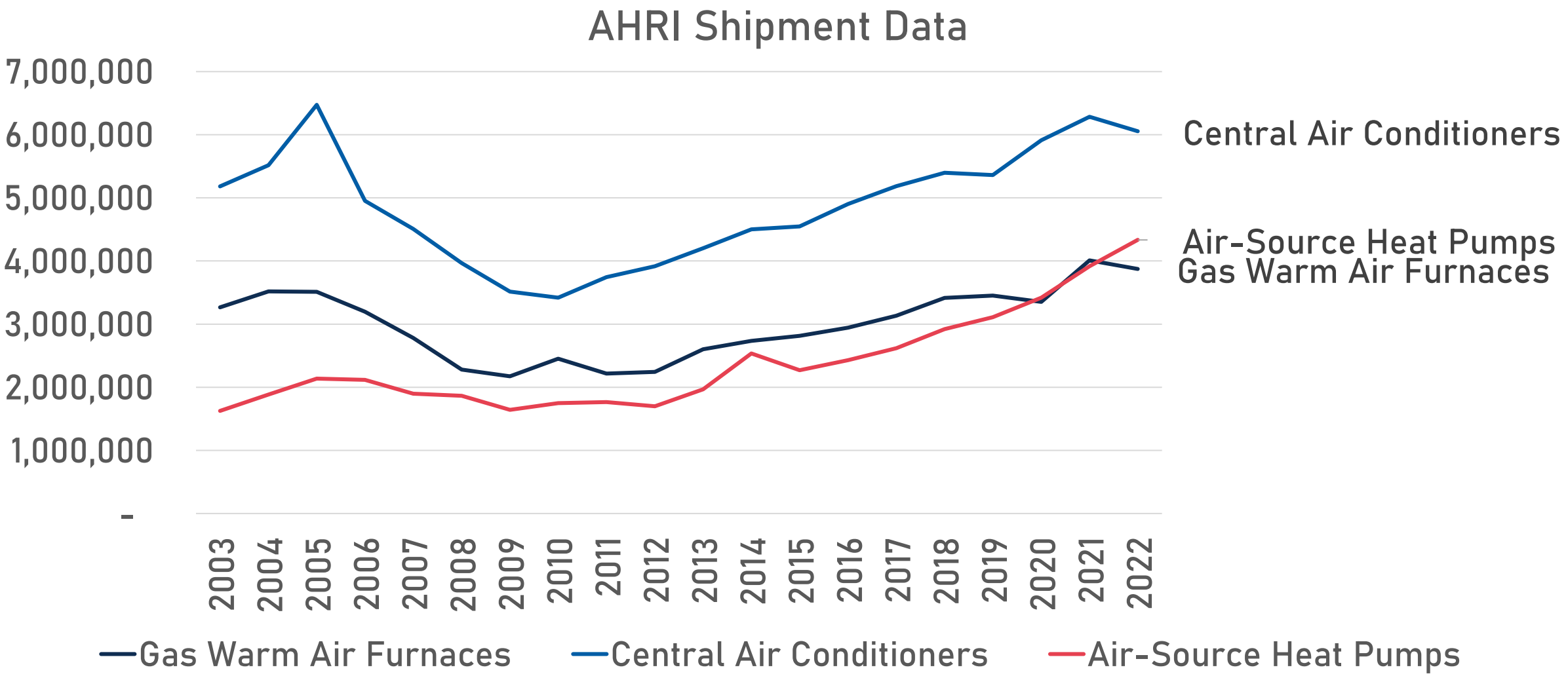
Consumer interest in heat pumps increasing



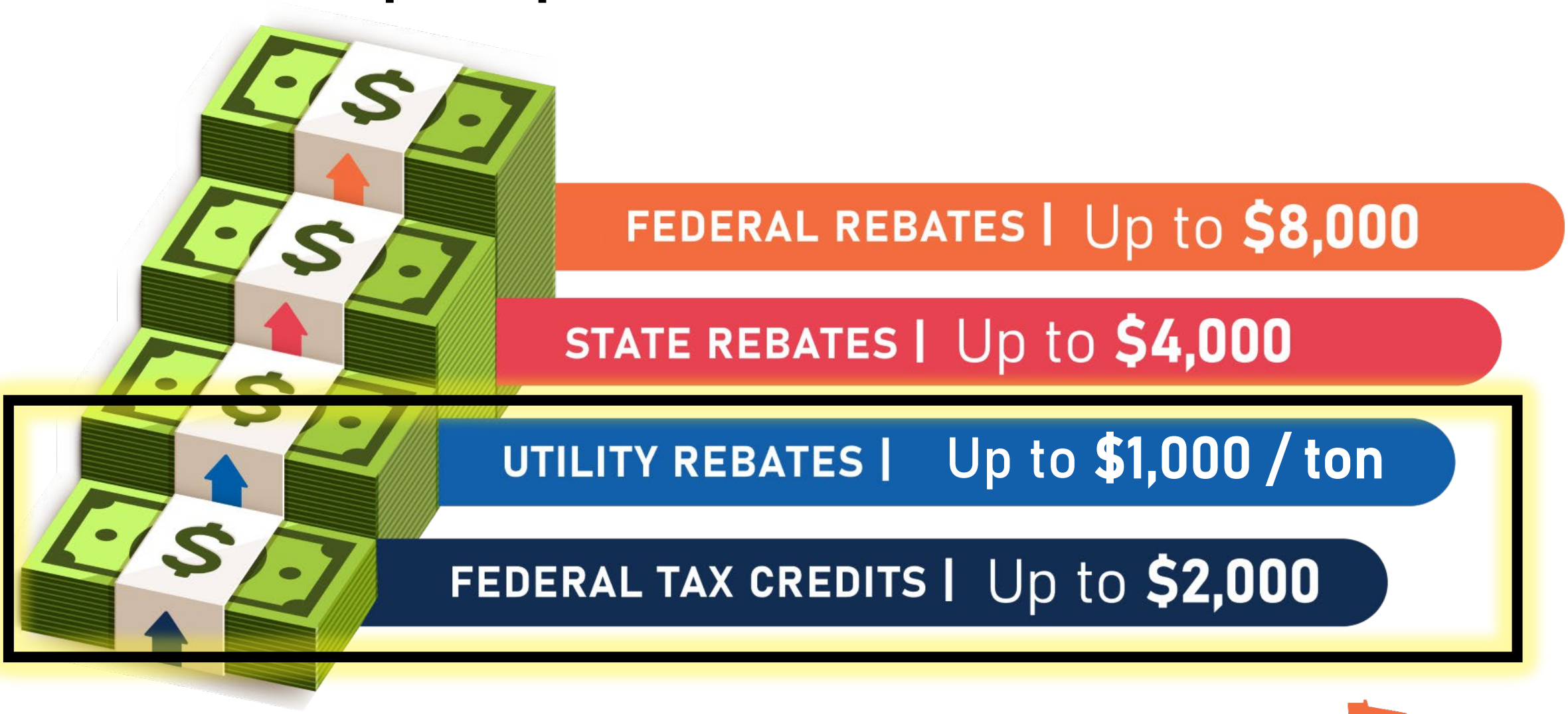
https://trends.google.com/trends/explore?date=today%205-y&geo=US-MN&q=heat%20pump

AC sales flattening and HP sales increasing



https://www.ahrinet.org/analytics/statistics/historical-data

The heat pump value stack



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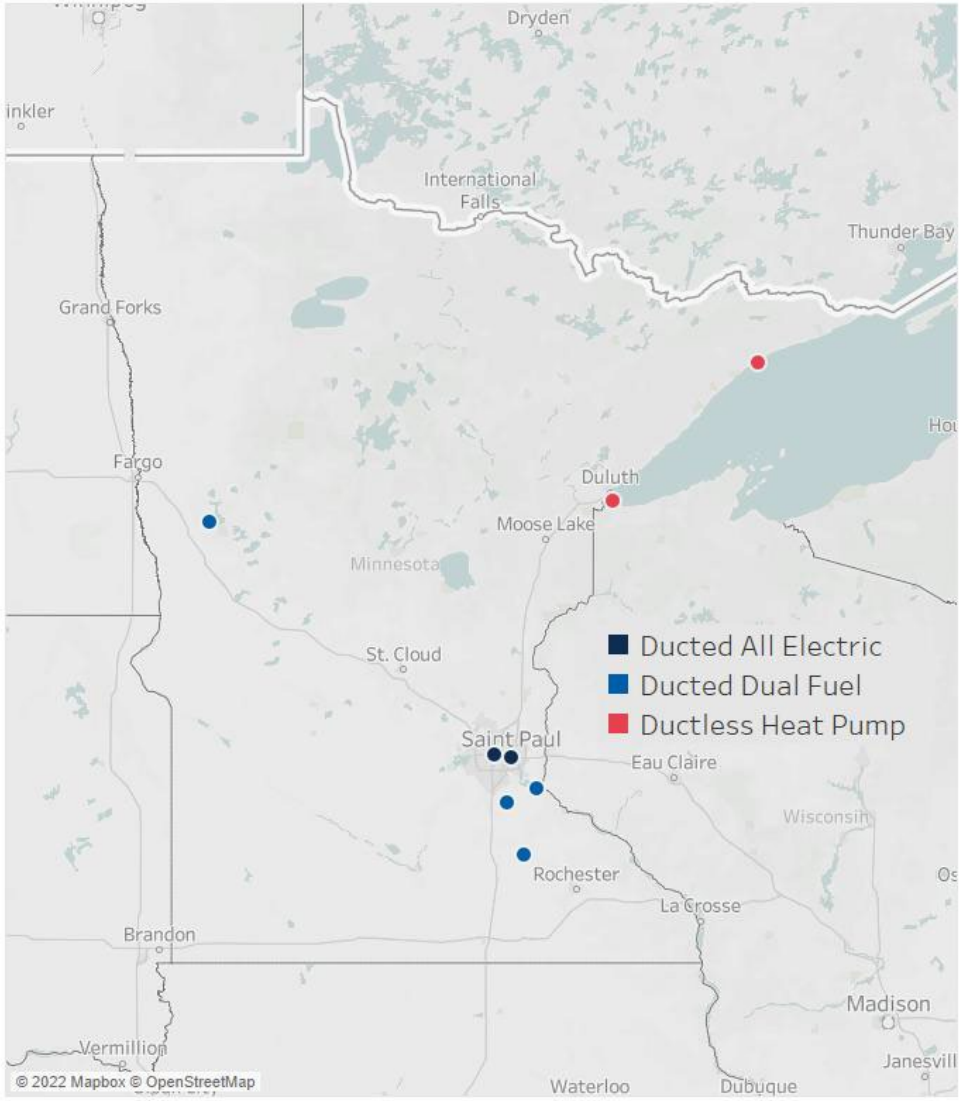
Initial field research: how do variable speed heat pumps perform in cold climates?

- 2 field studies
  - **CEE:** 8 ccASHPs installed in MN (2015-2017)
  - **Slipstream:** 8 ASHPs installed in WI (2019)
  - Propane and electrically heated homes
- Detailed data collection to monitor installed field performance of ASHP & secondary systems



Initial field research: how do variable speed heat pumps perform in cold climates?

CEE results:

- Significant customer bill savings
  - 55% over electric resistance, 30% over propane
- Systems were able to meet home heating loads at 10°F
- Systems were observed operating as low as -20°F

Slipstream results:

- 7/8 customers were satisfied with the ASHP

Annual Cost Savings		
Total	Total (% over baseline)	Propane Reduction
$579	28%	53%

https://www.mncee.org/cold-climate-air-source-heat-pump-field-assessment
https://slipstreaminc.org/sites/default/files/documents/publications/dual-fuel-air-source-heat-pump-pilot.pdf

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Variable Speed Heat Pumps as AC Replacements Study

Monitored 30 variable speed, coil-only heat pumps installed as AC replacements (2022-2023)

Key results:

- ASHPs sized the same as the preexisting AC often have more heating capacity than expected
- Similar average field results to brand-matched VSHPs
  - HSPF ratings not currently good predictors of performance
  - VSHP size to load ratio is best predictor of performance

This project was supported by ComEd's Customer Innovation program.

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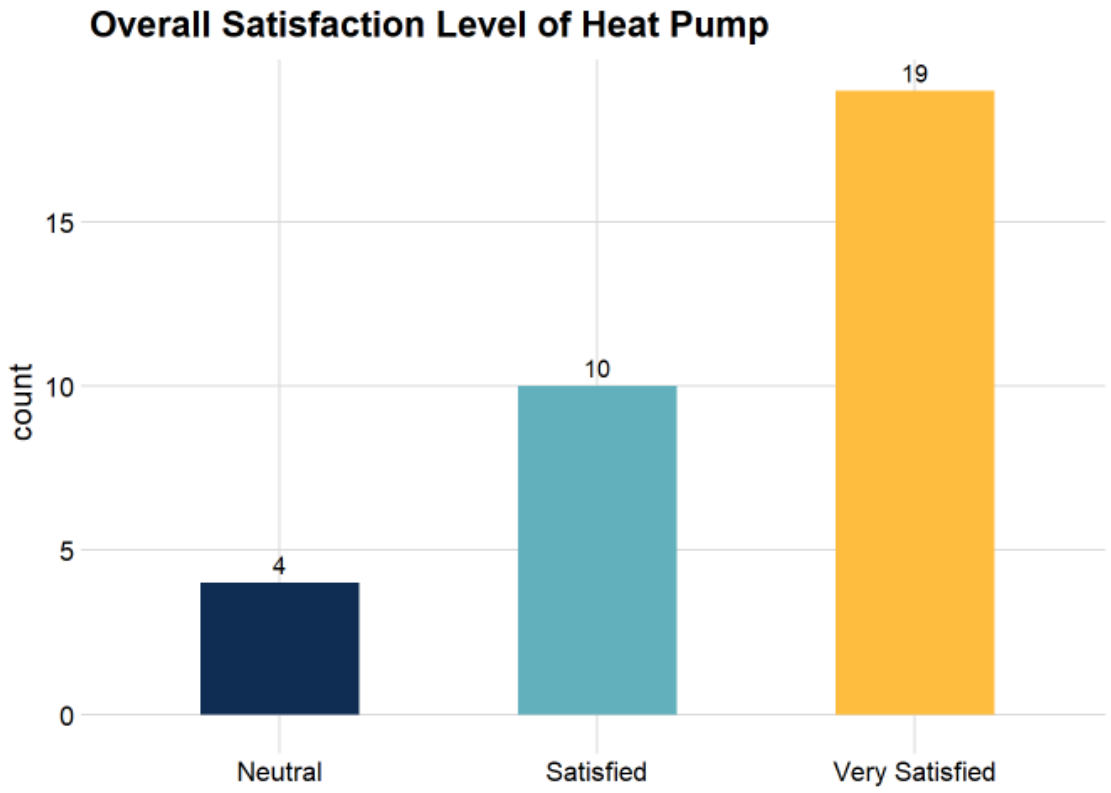
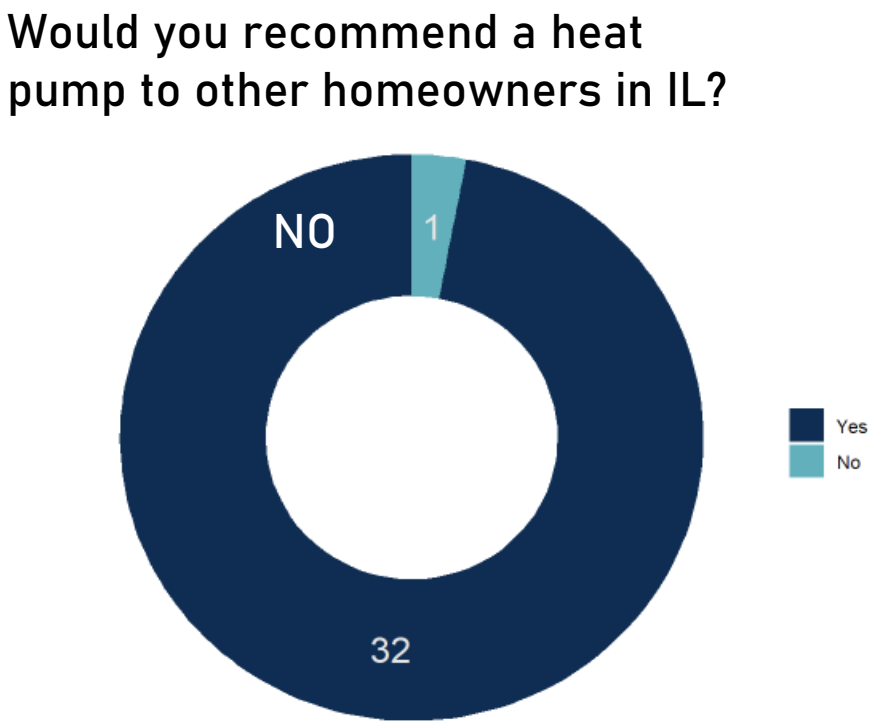
Homeowner Sentiments are Positive After HP Installs

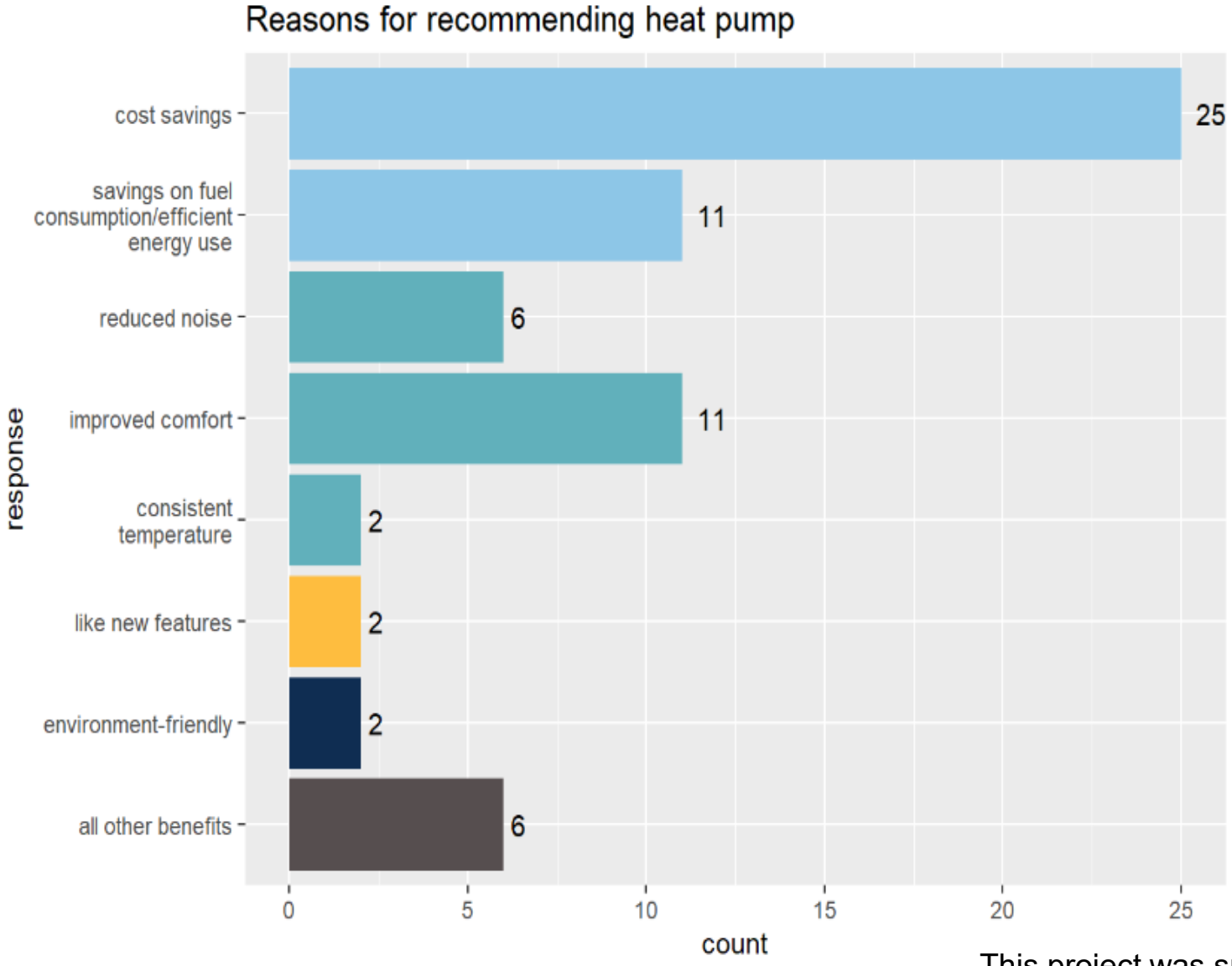
- No participants reported overall dissatisfaction; more than half very satisfied
- 96% would recommend a HP for AC replacement
  - “No” respondent said they “didn’t see the difference to recommend it” (C320)





This project was supported by ComEd’s Customer Innovation program.

Why would homeowners recommend VSHPs?



25 participants stated that they felt their VSHP **saved costs**

- 11 participants mentioned savings on **energy/fuel**

11 participants mentioned **improvement in comfort**

6 said the HP **reduced noise**

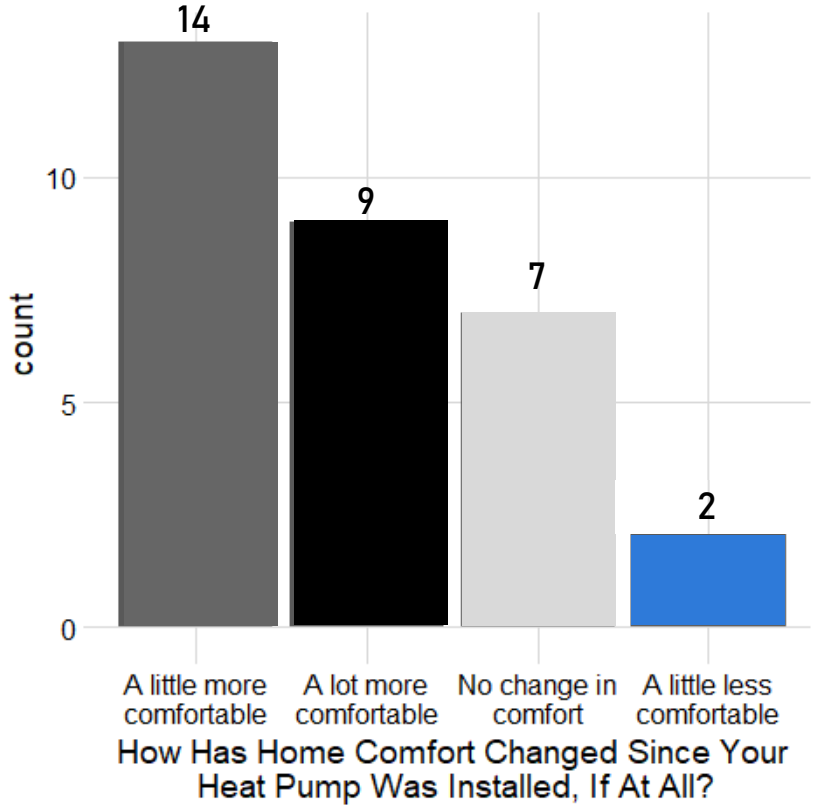
This project was supported by ComEd's Customer Innovation program.

VSHPs Usually Delivered Improved Comfort

Most Common Positive Sentiment Mentions:

Consistent temperatures

Better cooling

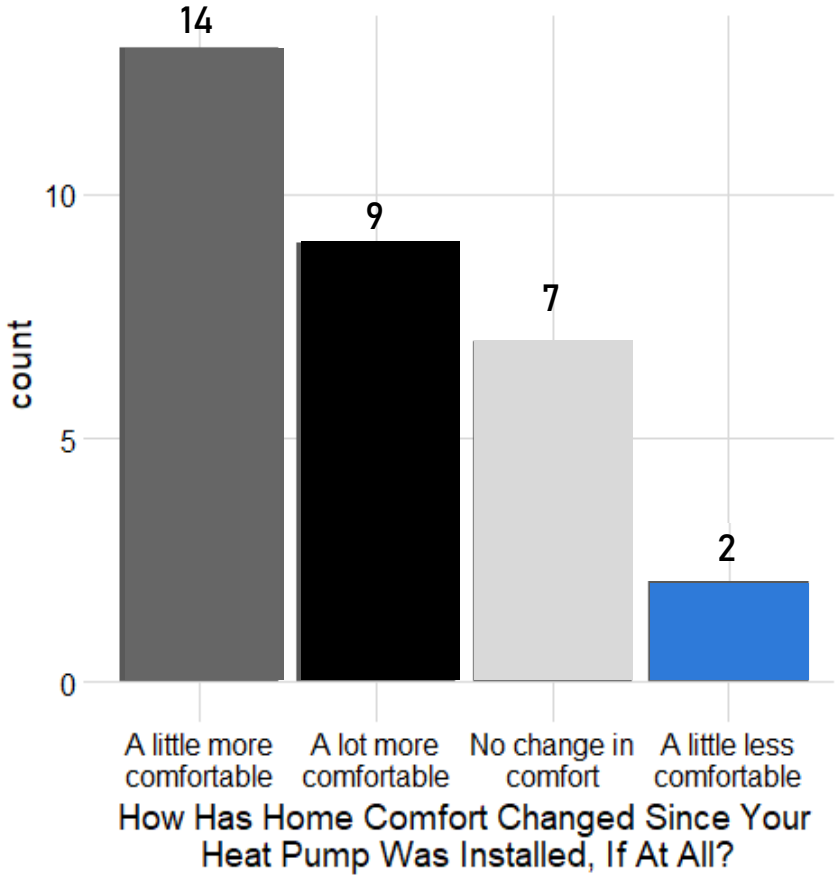


Comments from homeowners who felt **a lot more** comfortable:

- "The whole house is **even temperature**."
- "More **Even and consistent heating and cooling**"
- "Heat was so much **more even** throughout the house"
- "**more even and consistent** cooling and heating when the heat pump is operating"
- "Humidity control has been much **better in the summer**"
- "**Cools better** in the summer"
- "It's so much better overall! The **cooling is amazing** and the heat is great above 40F"
- "Heating was not appreciably changed but the temperature in the house is far **more stable**. **Cooling was a pleasant** experience. Although it did not seem to keep the air as dry as would have been comfortable"
- "We were more cautious about using the AC with he heat pump we keep the house a bit cooler."

This project was supported by ComEd's Customer Innovation program.

Reduced Comfort from VSHPs was Uncommon



Most Common Negative Sentiment Mentions:

Less "toasty or cozy" heat

Higher humidity in summer

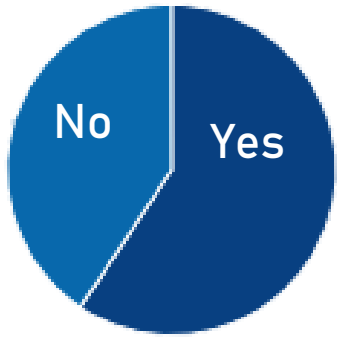
Comments from 2 homeowners who felt a little less comfortable:

- "Heat pump takes longer to heat when first started."
  - This homeowner used deep setbacks when away from home & at night
- "A little less toasty warm in the winter and a little more humid in the summer."
  - This site's HVAC was ~5x capacity/load

This project was supported by ComEd's Customer Innovation program.

Many Homeowners Changed Their Thermostat Use

Have you changed the way you use your thermostat since your heat pump was installed?



Types of reported changes:

Adjust setpoints

Reduce setbacks

Adjust when furnace vs HP heats

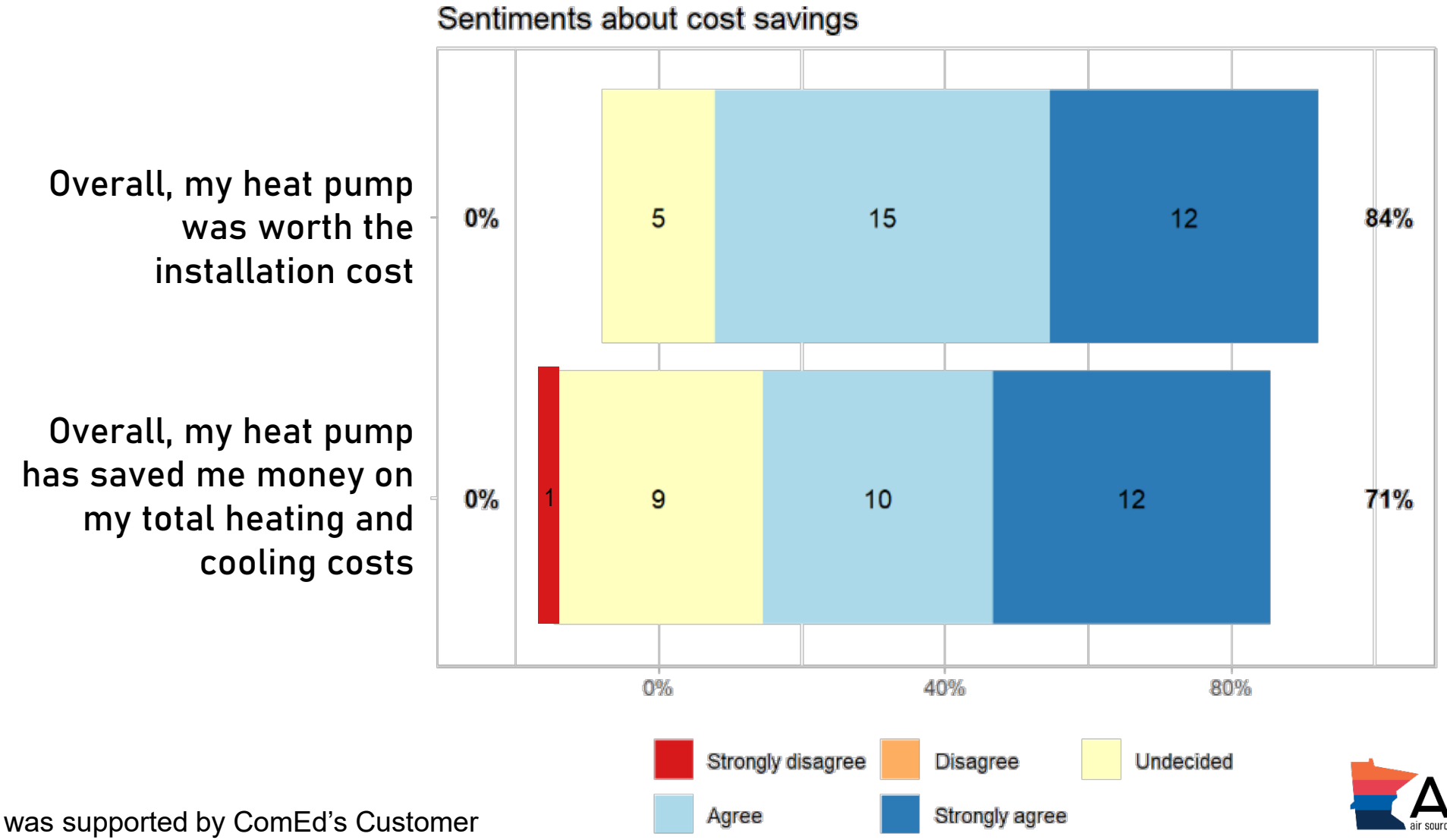
New thermostat has different features

Comments from homeowners who changed how they use their thermostat:

- "we were more comfortable overall and able to increase the temp in the summer and decrease it in the winter slightly while still feeling the same level of comfort"
- "I was able to set it at one temperature and leave it alone when using the heat pump. With just a furnace, I would turn the temperature up in the colder months."
- "We no longer use such large setback. "
- "Not as much set back in the winter time and tightened up the kick out time to **bring in auxiliary heat** when temps get very low. Initial settings did not work well, the unit could not recover from the night set back adequately when temps dropped to single digits. Once the house warmed up it was able to keep up."
- "When I want to quickly heat the house I **use furnace**."
- "the new thermostat is far more **basic in operation and features.** I don't like it as much."
- "I had a Nest and **new thermostat can't even program a schedule**"

This project was supported by ComEd's Customer Innovation program.

Homeowners Generally Agree VSHPs are Worth the Cost & Save Money; Some Undecided



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The heat pump wave: future proof your business

National shipment data and customer interest show the market is already growing

Increased utility rebates and incentives through the IRA and state legislation will continue to increase demand

Field research has validated equipment performance in cold climates and shown high levels of customer satisfaction

Even better equipment on horizon through DOE Cold Climate Heat Pump Challenge

Image source: https://en.wikipedia.org/wiki/Surfing#/media/File:Mavericks_Surf_Contest_2010b.jpg

ASHP Overview

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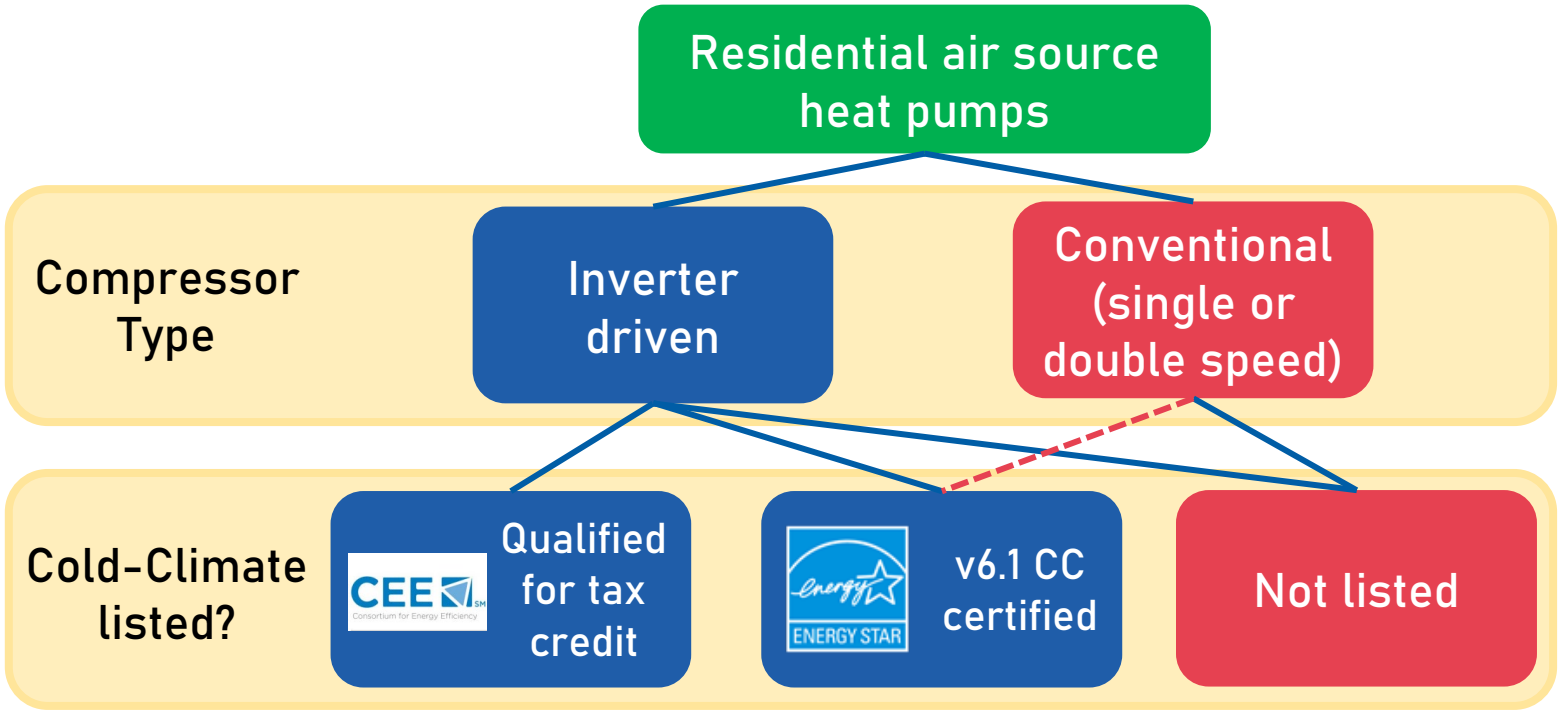
Level Setting Terminology



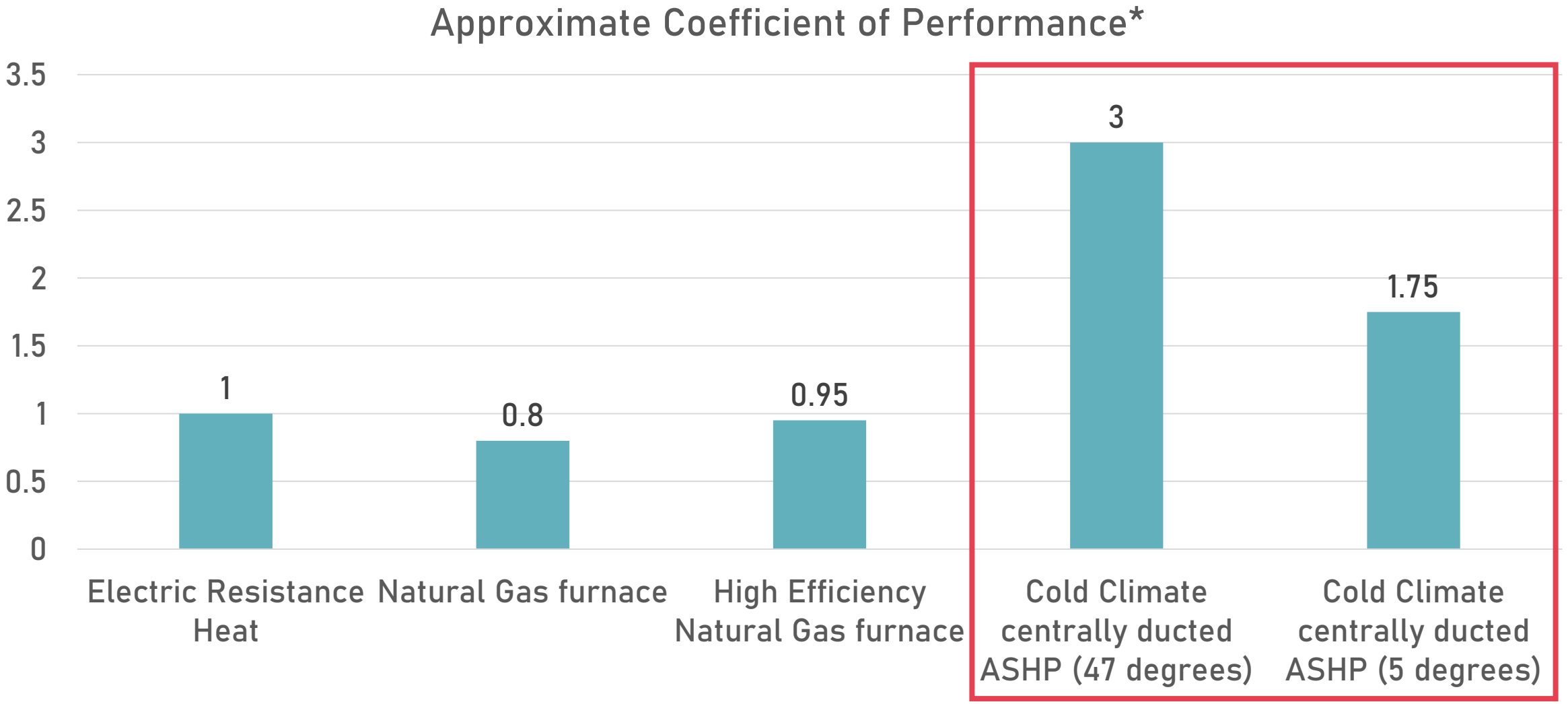
What qualifies as a “cold-climate” heat pump?

- Generally efficient at low ambient temperatures and can achieve capacity performance and maintenance

“Dual fuel” can mean many things

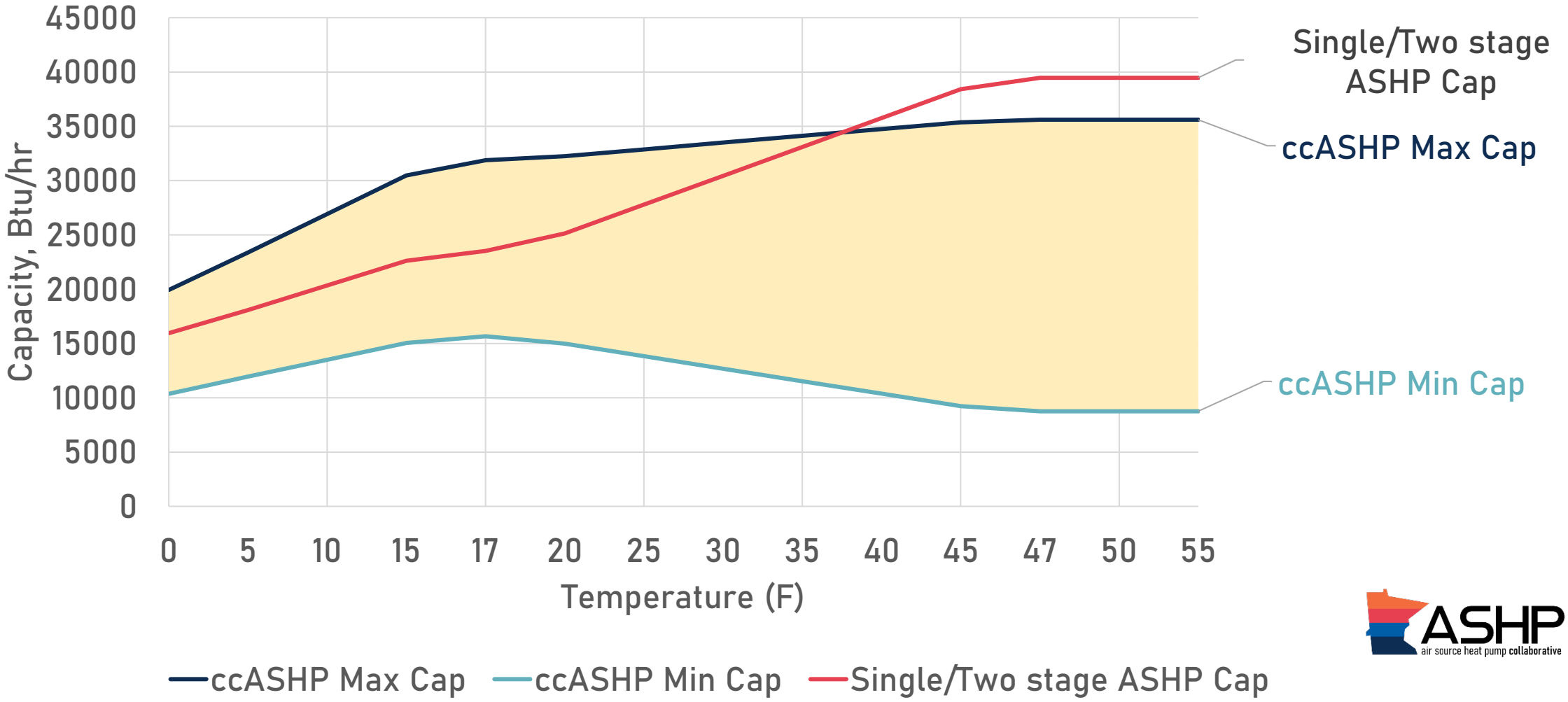
- Equipment compatibility
- Utility program description
- Always ask to fully understand the definition!

Are heat pumps more efficient than furnaces?



**Note – Natural Gas appliances don't use COP like heat pumps. AFUE = COP * 100*

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



Homeowner Support & Education

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What are customers looking for in an HVAC system?

Comfort

- Cooling in summer, heating in winter
- Less fluctuation around set point
- Temperature consistency and balance around home

Economical Solutions

- Upfront cost vs operational cost vs maintenance cost
- Incentives & rebates

Customization

- Ease of modifying settings depending on how preferences change
- Remote/Wi-Fi connectivity

Ease of Use

- “Set it and forget it”
- Reduced effort from customer to ensure their system is working as expected for their needs

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Sales approach will not change between a heat pump vs an AC or furnace - how can you become comfortable with heat pump technology and make simple modifications to your sales process?

Customers may not be happy with how their current system is operating – how can you solve these issues by proposing a heat pump option?

Key Strategies

What needs to be done to prioritize customer satisfaction and improve business operations?

- Utilize tools and resources to help the customer understand the design and installation, maintenance, and service processes
- Prioritize customer education to ensure they understand how their new system will operate
- Incorporate comfort consultation into your sales and troubleshooting processes
- Use an installation checklist to ensure you're completing all necessary tasks AND ensuring customer confidence in your work

This icon will be used to call out opportunities to improve customer experience & business operations.

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Homeowner Education

Well-installed outdoor + indoor units = satisfied homeowner

- Register / supply air temperatures
- Switchover temperature / interaction with supplemental heat
- Thermostat settings (setback, fan speed)
- Defrost cycle
- Maintenance (snow removal, filters)

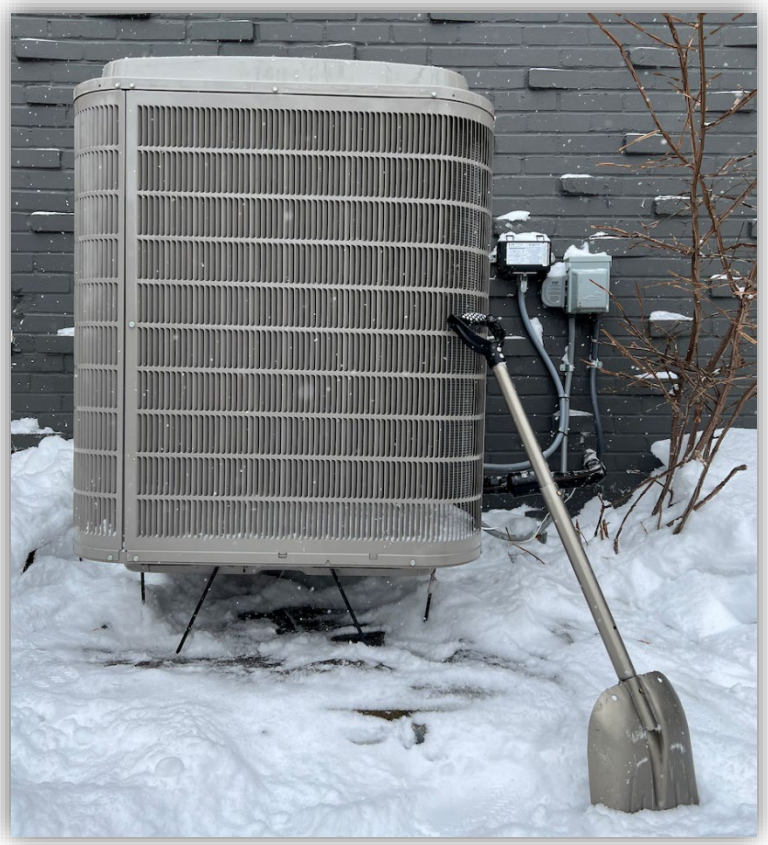

Photo credit: Jeff Curtes, Auer Steel

Happy, well-educated homeowners are the best salespeople!

Benefits and Considerations by Application Type

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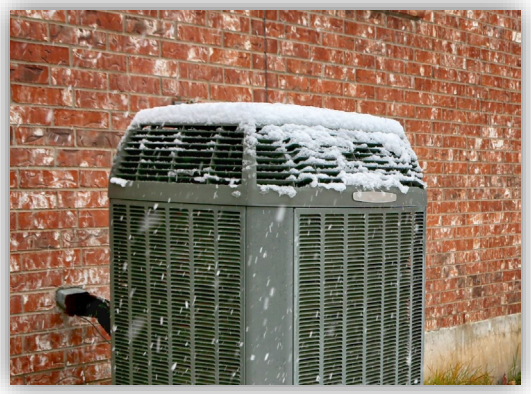
Benefits by application type

Ducted, dual fuel heat pump

- Ideal for AC replacement and to displace gas furnace
- Works well with high efficiency gas furnace
- Resilient and future proof

Ducted, all-electric heat pump

- Ideal for when both furnace and AC are ready to replace
  - Ideal for high performance, propane systems, poor functioning/older systems
- Good option for customers interested in reducing their carbon impact



Discussing application types and their benefits is a great opportunity for homeowner education!

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Considerations by Application Type

Dual fuel only

- Size up to the heating load for ER & propane
- Size to the cooling load for natural gas
- Understand homeowner motivations to select correct switchover temperature using balance points

All-electric only

- Size for the heating load and ensure cooling load will be met
- Reference max capacity at 5°F
- Electric panel capacity
- Use capacity balance point for switchover temperature, or 5°F

Both

- Ductwork & airflow analysis
- Building envelope, weatherization
- Compressor locations

Sizing and Design Considerations

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Does sizing impact energy use and utility bills?

What's wrong with inaccurate load calculations?

- For single and two speed systems, maximum efficiency happens during long run times, not starts and stops.
  - This LIKELY has small energy penalties for too-large systems oversized by more than 33%.
- For variable capacity equipment, longer run times may mean more time spent at medium and low heat/fan speed.
  - This LIKELY has energy penalties for systems oversized by more than 40% as they potentially will not have shorter run times at higher heat/fan speed.
- Wrong sized for the ductwork can lead to much higher fan watt draw.
  - An AHRI report showed that adding static pressure to Electrically Commutated Motors only reduced flow from 1 to 3% with increased fan power draw up to 48%!

NIST, NREL, Proctor Engineering, Illinois Institute of Technology

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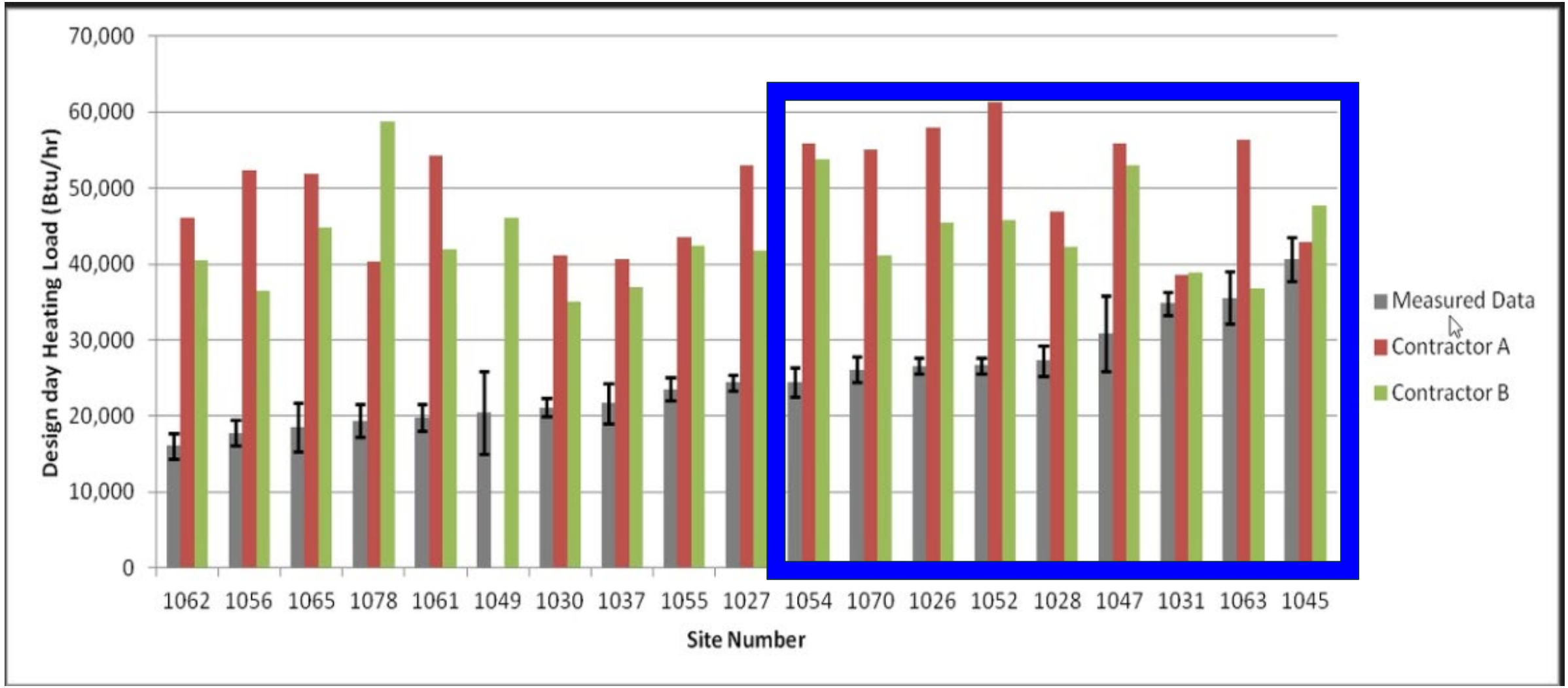
Example of why not to add weights to Manual J

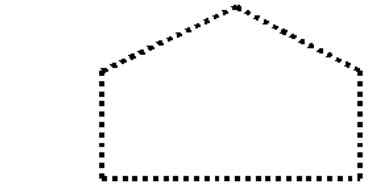


Sizing - Rules of Thumb

- One Ton Per 400 sq ft
- 35 btu per sq ft
- One cfm per sq. ft. of house
- Tonnage = half the number of cylinders in the customer's biggest car/truck
- What's available in the shop today
- ½ ton bigger than their neighbor
- This online Rule of Thumb tool I found!

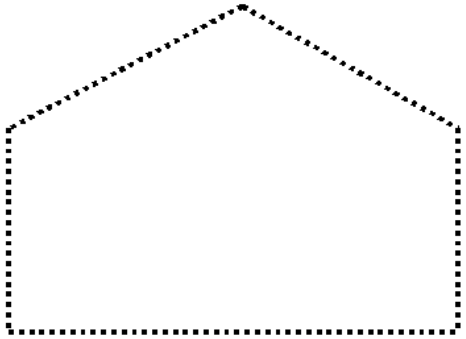
Air Conditioner or Heat Pump Sizing Chart

(Please understand that this is meant as humor,
however it is just as accurate as "x" number of square feet per ton!)



1 1/2 to 2 ton

2 1/2 to 3 1/2 ton



4 to 5 ton

Slide courtesy Bruce Manclark, CLEAResult

Sizing considerations – Must have a load calculation!

Level of load calculation time and effort required

Low

- Sized off existing equipment size
- Using rules of thumb

Medium

- Comfort consult + block load (Man J equivalent)
- Existing equipment – with run time or utility bills

High

- Room-by-room
  - Manual J or equivalent
  - Detailed envelope information needed

Example enhanced rule of thumb

Heating Load Estimator (*in BTUs per square foot of floor area*)				
	Local Design Temperature			
House Description	**Below -10˚ F**	**-10˚ F to 5˚ F**	**5˚ F to 20˚ F**	**Above 20˚ F**
No-wall Insulation; single pane window	47	41	35	29
2x4 wall w/ insulation; 2P windows	25	22	19	16
2x6 wall w/ insulation; 2P windows	18	15	13	11
New Construction (Post 2012)	16	14	12	9

Chart courtesy of the Northwest Energy Efficiency Alliance

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What other real-world scenarios exist regarding oversizing?

Run times matter; longer run times are better

- Improved filtration, dehumidification, home destratification
- Reduced temperature swings compared to on-off operation
- Maximum efficiency achieved in single & two-speed systems
- More time spent at medium and low heat/fan speed in variable speed systems

Larger compressors and fans may be noisier and require larger electrical circuits

Oversized systems may struggle with existing ductwork

Why is it important to understand ductwork implications?

- Increased fan energy use
- Increased noise
- Capable of delivering the air where it needs to go
- More regular fan motor replacement
- Not getting the capacity you (the homeowner) paid for
- Coils freeze/ice over during cooling season

Airflow Before Charge – the mantra of service technicians everywhere!

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Evaluating existing ductwork

1. Engaged discussion with homeowners and qualitative test – does the existing system and ductwork deliver hot/cold air to all rooms?
2. Visual inspection of the ductwork:
    1. Is it located in attic and unconditioned basement?
    2. Are the ducts visually damaged or leaking?
    3. Are the ducts properly insulated?
3. Perform static pressure test(s).
4. Record static pressure and identify key components that will add to static pressure build up.

Envelope Consideration – When to install the heat pump?

Is the homeowner considering or willing to weatherize?	What should we discuss or do in response?
No, this is an emergency replacement	Can we install a heat pump that is flexible to future lower loads?
Yes, they are very interested in improved comfort, lower bills, and right sized mechanical systems	Best to install HP at the same time or after weatherization is completed!
Not sure, but want to learn more	Can we introduce the homeowner to a weatherization service?

Ask yourself how this approach would reflect on you to a homeowner!

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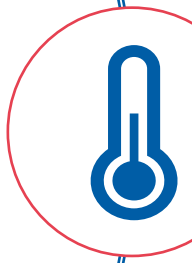
Sizing and Design – Key Takeaways

Equipment is very often oversized – this is why good load calculations are important!



Sizing should always include home insulation and design temperatures in addition to home size.

Ductwork should always be assessed to understand the impact it will have on equipment performance.

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Equipment Selection

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General Design and Selection

- Design and selection….
  - **Involves applying the results of heating and cooling load calculations to ensure that the selected equipment is correctly sized to deliver the load requirements**
  - **Needs to include existing conditions and application type**
- Summary from NEEP:

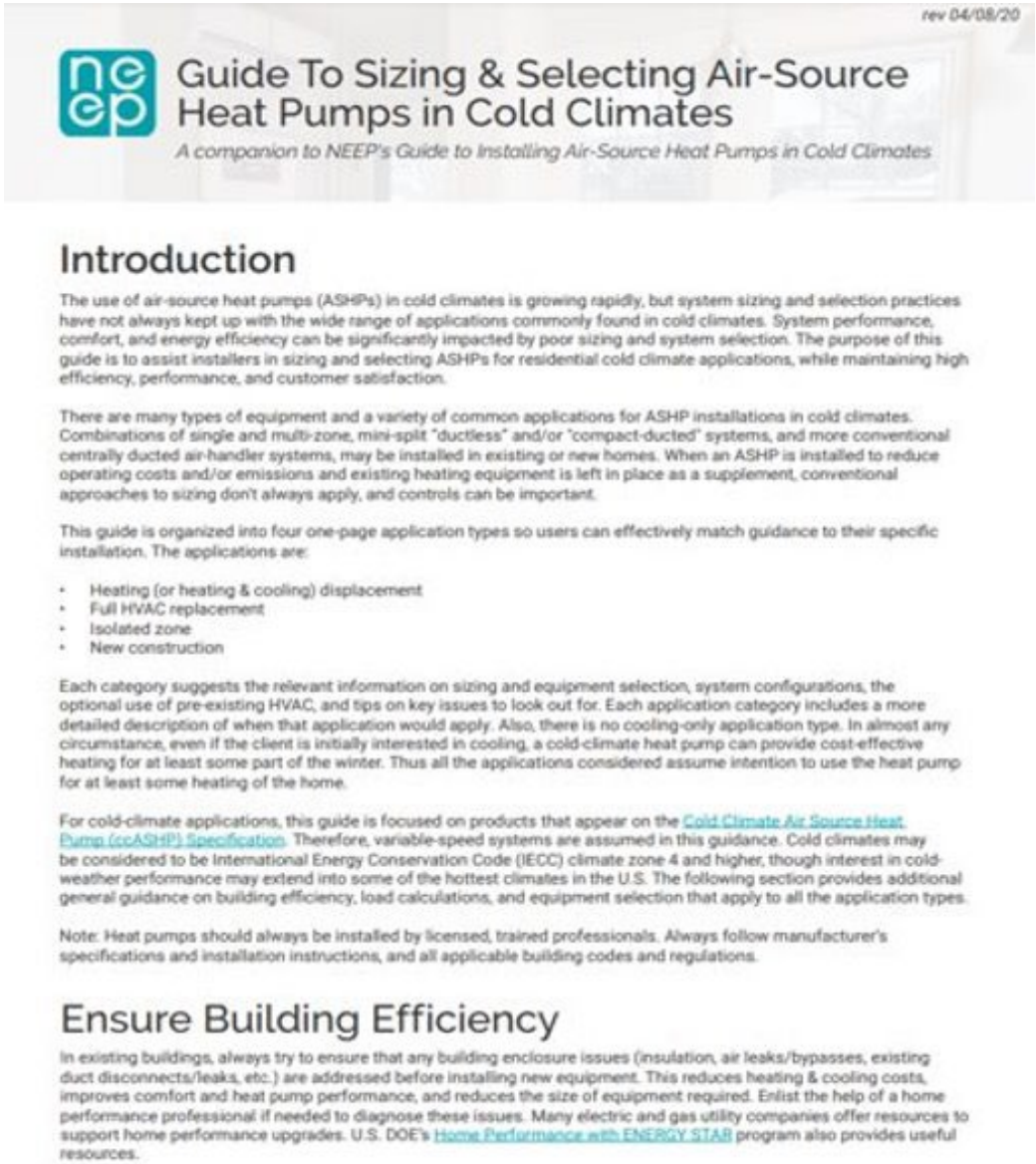
Manual S: Summary

Manual S directs, for central air conditioners and heat pumps, that:

- The selected equipment will satisfy the building's total load requirements at design conditions
- Manufacturer's product data shows that latent loads are met
- Total equipment capacity is between: - 95% and 115% of total cooling requirements (for air conditioners and heat pumps) *or* - 95% and 125% of total cooling requirements (for heat pumps in heating dominated climates).
- It allows stepping up to the next largest nominal piece of equipment, per the desired product line, that is available to satisfy both the latent and sensible requirements.

Sizing Guidance Resources

- NEEP Installer Resources – Guide to Sizing and Selecting Heat Pump
- NRCAN Air-Source Heat Pump Sizing and Selection Guide



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 resources.

Technical Sizing and Customer Confidence with a Cool Tool

- Reduce callbacks
- Your confidence in product selection
- Your customer's confidence in your proposal/bid
- Differentiating yourself in the market

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

Product Type

All Product Typ

Ducting Configuration

All Ducting Co

Brand

All Brands

AHRI, Model, Unit

AHRI, Model or Ur

Heating Capacity 47°F Rated Btu/h

0 80000

Heating Capacity 5°F Max Btu/h

0 80000

ENERGY STAR Certified

- ENERGY STAR V6.1
- ENERGY STAR V6.1 Cold Climate

Eligible for Federal Tax Credit

- North
- South

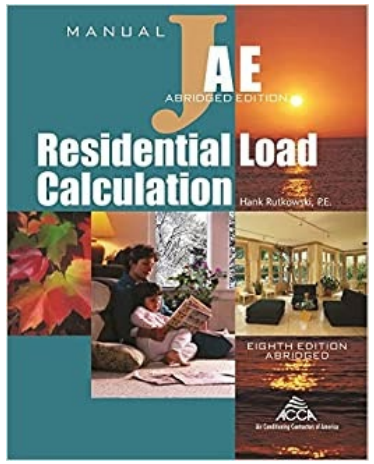
SEARCH THE LIST

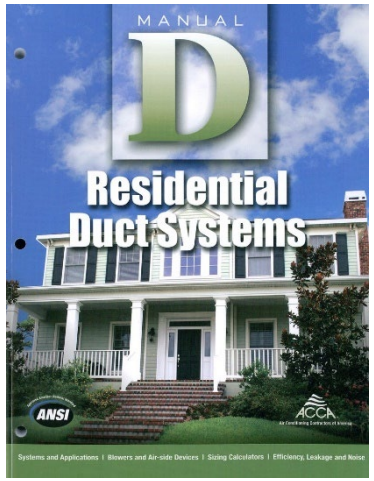
Advanced Search - Sizing for Heating

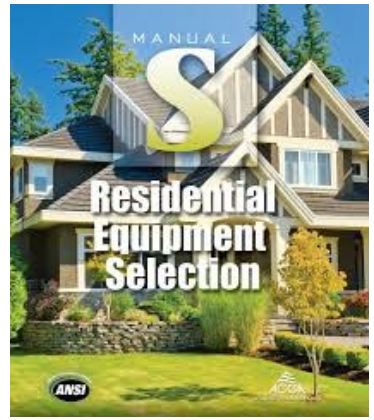
Advanced Search - Sizing for Heating User Guide

Design Challenges

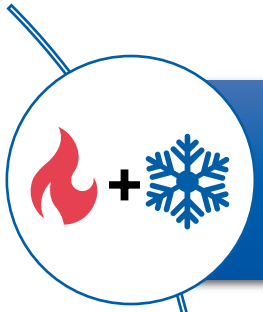
- Accurate load calculations
- Determining when to size for heating vs cooling
  - AC replacement – always size for cooling
  - Cheap “backup or supplemental heat” – size for cooling
  - Expensive backup heat or carbon as driver – size for heating and cooling
- Distribution (ductwork) not properly designed for variable speed equipment
- Set expectations for performance with homeowners
- Selecting the right heat pump for the use case
- Selecting the best control strategy for the customer and equipment







Equipment Selection – Key Takeaways



Always consider both heating and cooling loads from your sizing calculations.

Select equipment so that the cooling capacity is not more than a ton larger than the cooling load.

Utilize resources and tools to help you confidently select the correct equipment for each application.

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Controls Strategies

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Thermostat Selection & Configuration is a Critical Difference between HPs and ACs

NOT ALL THERMOSTATS ARE DUAL FUEL COMPATIBLE

Selecting a heat pump compatible thermostat is NOT enough

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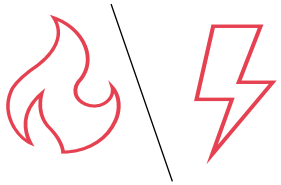
Thermostat features to look for:

4 or more wires / wireless

- Must be able to control the HP reversing valve to operate both heating and cooling modes
- Wireless thermostat models exist

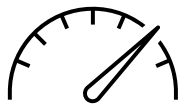


Dual fuel controls software

- Some thermostats can control a HP but not a HP with a backup heat source

Outdoor air temperature monitoring

- Can be a hardwired sensor, wireless sensor, or WiFi connectivity to a local weather station*
- Required to set a condenser lockout temperature



Multiple stage heating controls

- Optional, but may improve comfort or eliminate condenser lockout at low temperatures

**Supply air temperature sensors can also be use in this role for many systems*

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Balance point definitions

These balance points can be used to set the switchover temperature

Thermal balance point	▪ The outdoor temperature at which the heat pump can no longer produce the heat needed for the home. ▪ Also called capacity balance point.
Economic balance point	▪ The outdoor temperature at which the cost to heat the home with the HP is the same or more expensive than the back up heat cost. ▪ Dependent on both gas and electric rates.
Comfort balance point	▪ The outdoor temperature* at which the homeowner experiences discomfort when running the heat pump. ▪ Typically, the thermal/capacity balance point + a few degrees.

*This could be an indoor temperature measure with a supply air temperature sensor

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Auxiliary heat control methods

Ducted Dual-Fuel Systems

- Setting the switchover temperature using balance points* as guidance
- Setting a droop temperature – integrated thermostat

Ducted All-Electric Systems

- Setting an auxiliary heat lockout temperature
- Upstaging by time
- Upstaging by droop temperature

Ductless Systems

- Setting a droop temperature using a two-stage thermostat or separate thermostats
- Installing integrated controls (better for new construction)

**Some dual fuel third party thermostats don't use the term switchover or balance point*

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Droop method

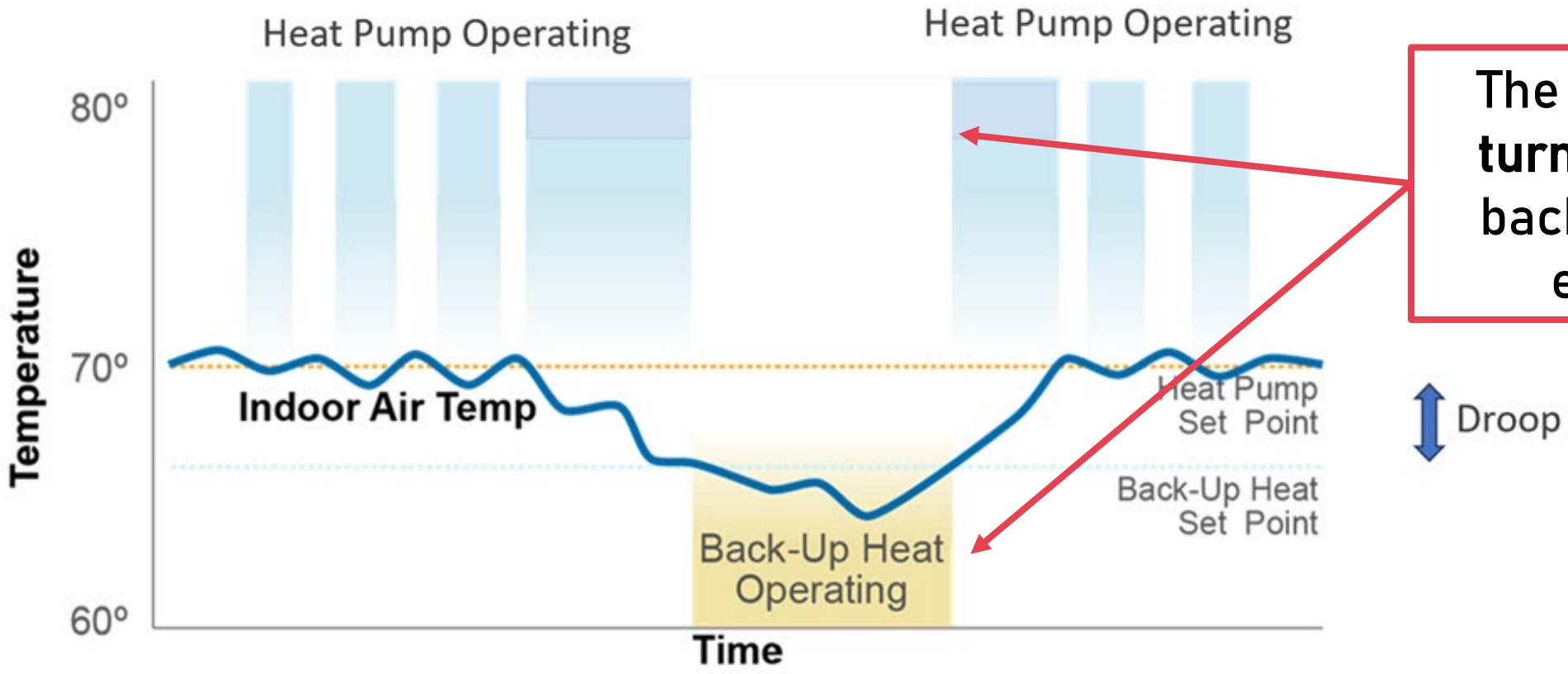
- Droop is a specified temperature value that defines the maximum allowable temperature swing below the heating setpoint before backup heat is engaged.
- Droop can be set to either fully engage or upstage backup heat depending on the system type.
- Once backup heat is activated, it will add heat until the indoor air temperature matches the setpoint.

Indoor Temp Set Point	= 70° F
Droop Setting	= 3° F

70° F – 3° F = **67° F**

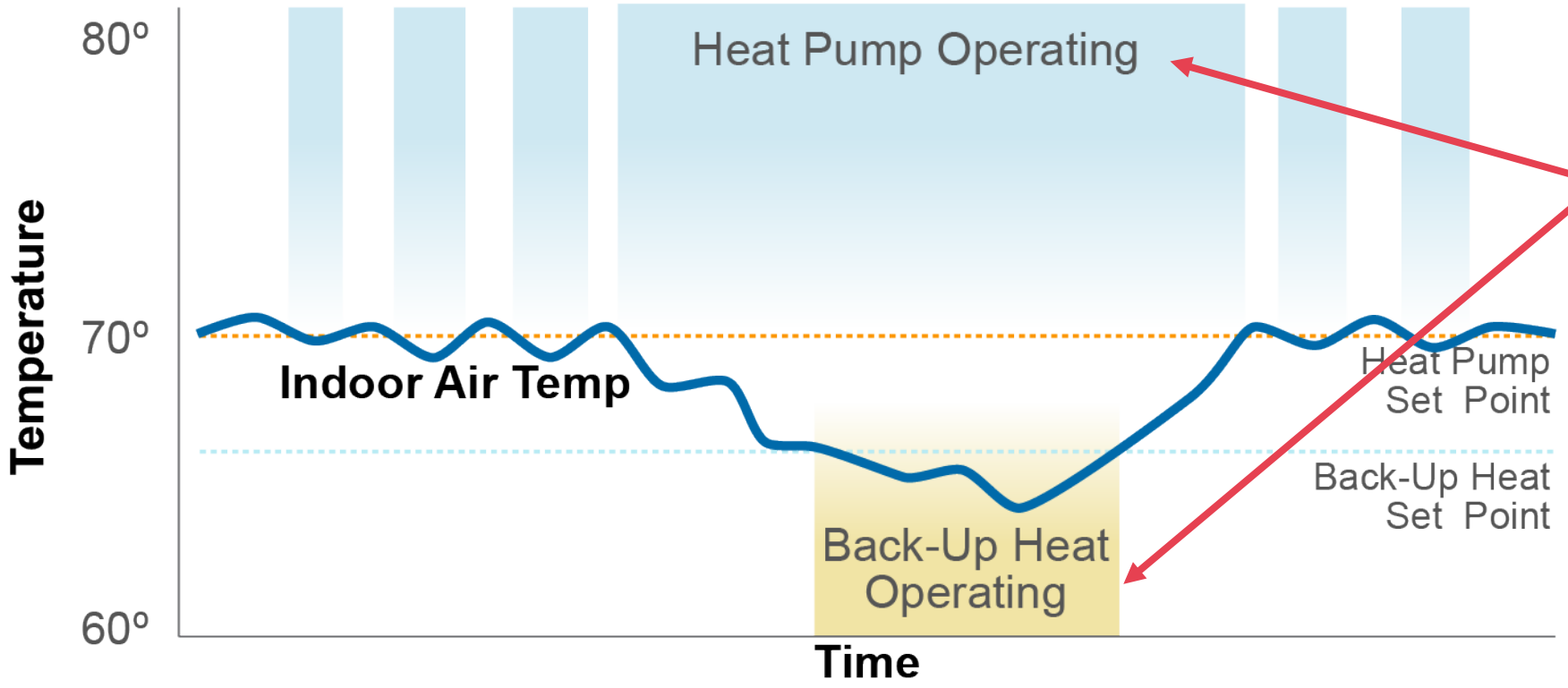
Since the droop is set at 3° F below the set point 70° F, the backup heating system will engage when the indoor air temperature is measured to be **less than 67° F.**

Droop method – Ducted dual-fuel systems



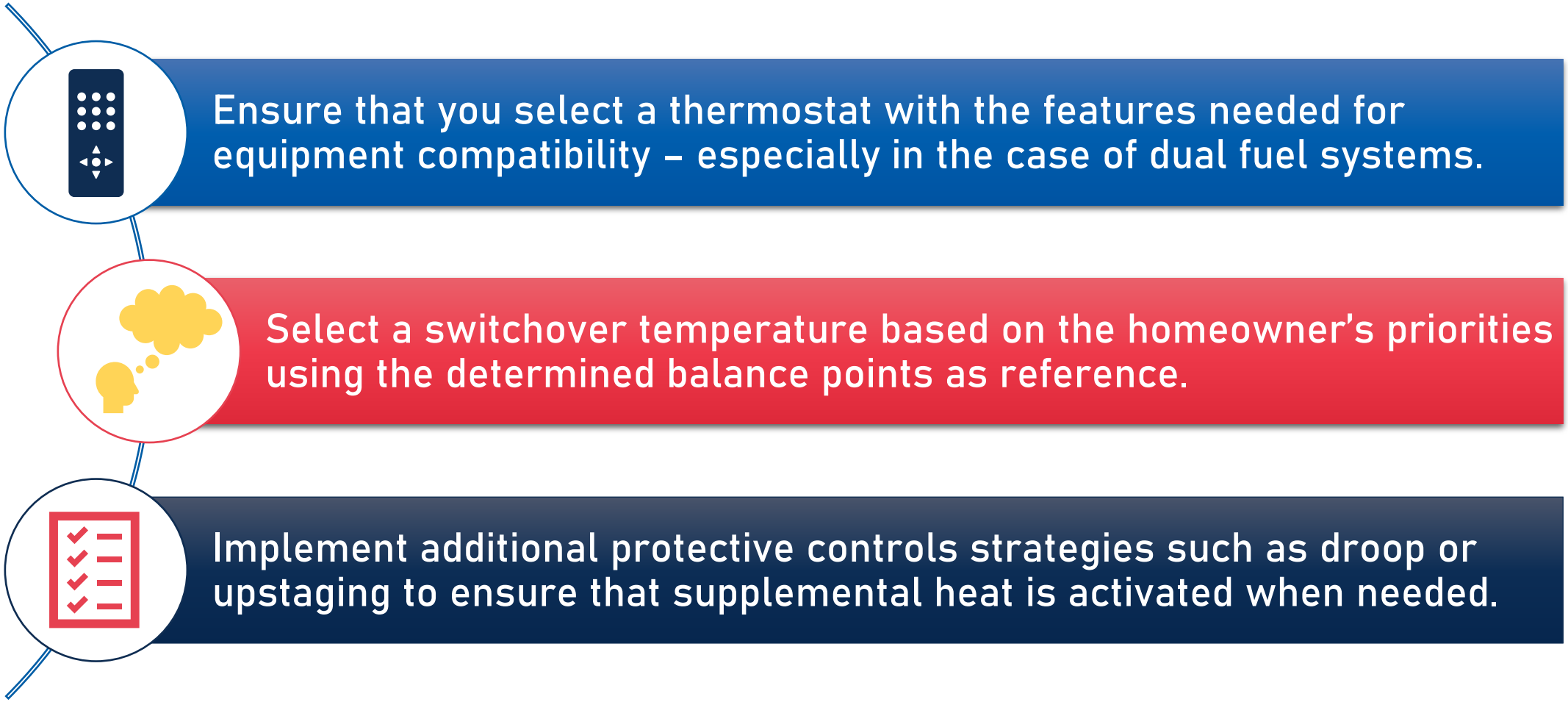
The heat pump **turns off** while backup heat is engaged

Droop method – Ducted all-electric or ductless systems



The heat pump **remains on** while backup heat is engaged

Controls Strategies – Key Takeaways



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Installation Considerations

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Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Compressor placement – what is incorrect about the photo below?

- Unit is placed in a walkway – melt water can refreeze on ground surfaces and create a slip hazard

- Correct placement away from a walkway

Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Compressor placement – what is incorrect about the photo below?

- Unit is placed under a drip line – moisture can refreeze on the compressor's coil surface

- Correctly placed away from dripline (no moisture refreeze on unit)
- When needed, outdoor units should be installed with drip caps or shields

Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Compressor placement – what is incorrect about the photo below?

- Unit is installed facing into the dominant wind direction – can cause counter-rotation of the outdoor fan.
- This can lead to failure of the fan motor, fan circuit, or both.
- Wind baffles can be installed if there is no other location for the outdoor unit.

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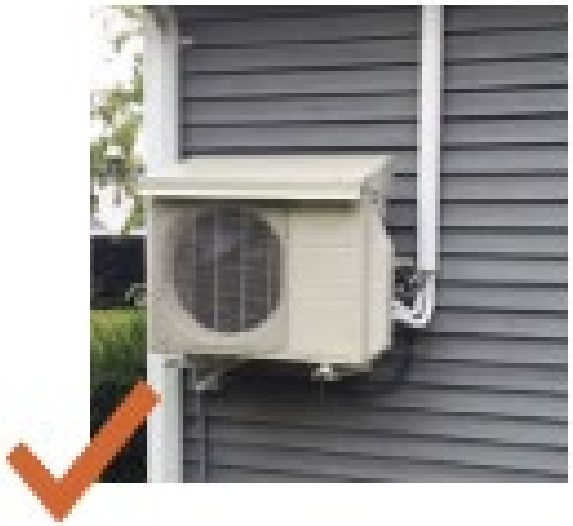
Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Compressor placement – what is incorrect about the photo below?

- Placement next to a window may result in noise disturbing occupants (especially if there is little insulation or single pane windows).
- In colder climates, defrost cycle and full power operations occur frequently.



- Unit is placed away from a window where the noise will not disturb occupants.

Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Compressor placement – what is incorrect about the photo below?

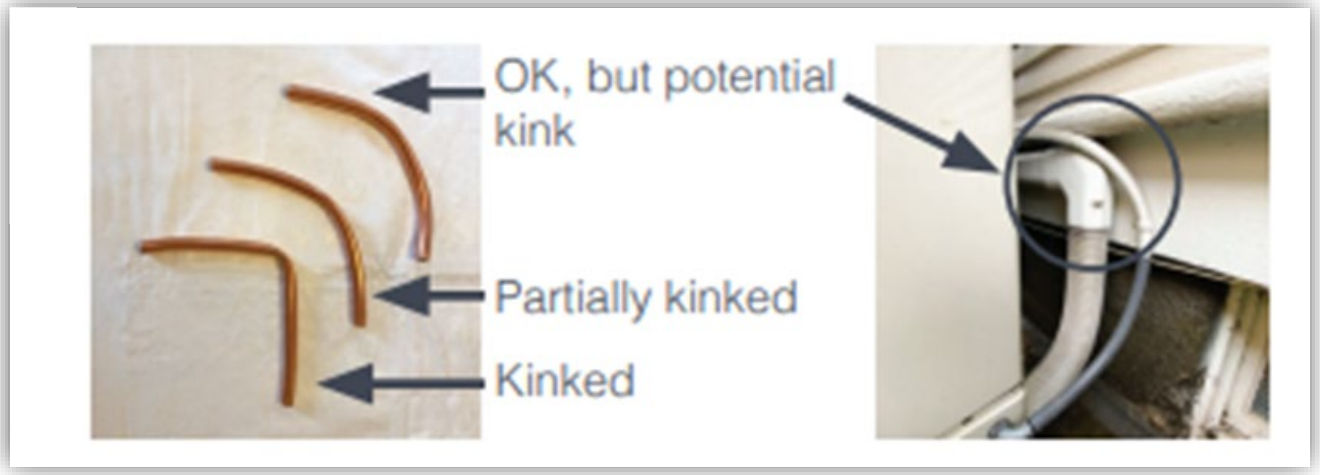
- Snow is blocking free-flowing air, which will negatively impact equipment operation.

- Unit is installed with an equipment stand/platform – wall brackets can also be used to raise the unit above the snow line.
- It is critical to educate the homeowner on the importance of snow removal around the unit.

Installation considerations

Images courtesy of the Northwest Ductless Heat Pump Project

Line Set Installation



- Avoid any kinks or partial kinks in the line set.
- Even a partial kink can result in reduced capacity in low temperatures – this could result in a callback and may be a difficult problem to solve!
- It is also essential to insulate the entire line set, including the flare nuts.

Surge Protection

- Highly recommended for any system that has microprocessor components
  - All variable-speed equipment and many single and two-stage products.
- Low-cost option for the benefit it provides.
- Product options
  - Some products may only handle one surge, while others can handle multiple surges.

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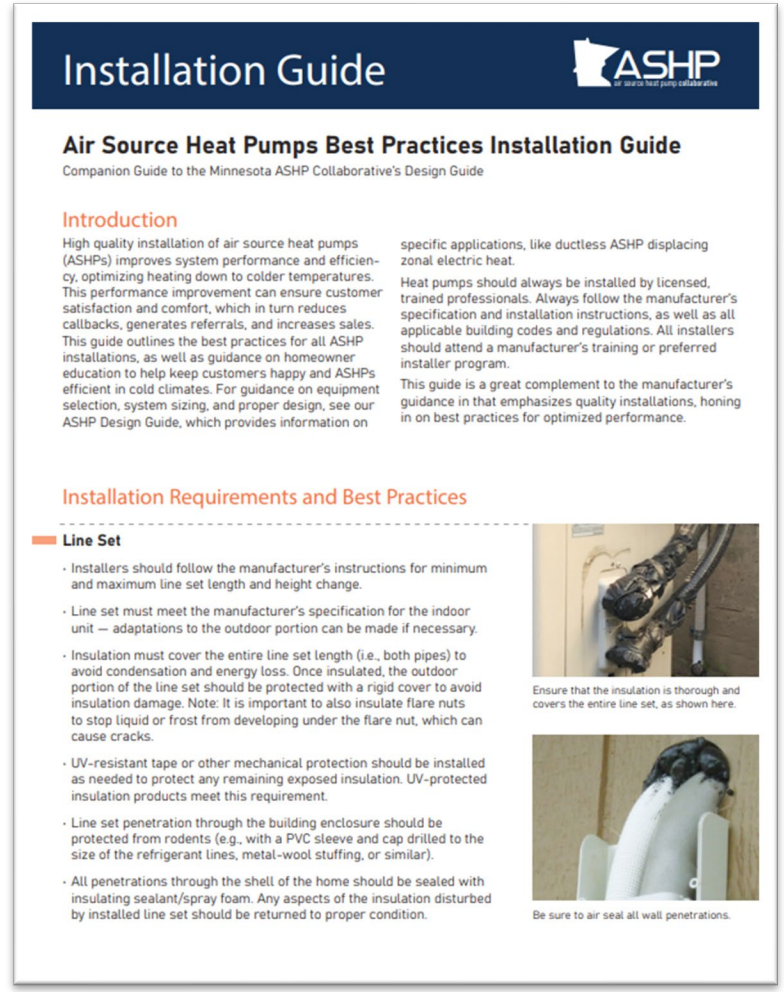
The Best Practices Installation Guide

This guides how the MN ASHP Collaborative performs the site verification process for the Preferred Contractor Network.

Content Sections

- Line Set
- Refrigerant Charge and Tubing
- Condensate Drain
- Outdoor Unit Installation
- Homeowner Education & Additional Resources



Installation Guide

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Air Source Heat Pumps Best Practices Installation Guide

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 specific applications, like ductless ASHP displacing zonal electric heat.

Heat pumps should always be installed by licensed, trained professionals. Always follow the manufacturer's specification and installation instructions, as well as all applicable building codes and regulations. All installers should attend a manufacturer's training or preferred installer program.

This guide is a great complement to the manufacturer's guidance in that emphasizes quality installations, honing in on best practices for optimized performance.

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.

Ensure that the insulation is thorough and covers the entire line set, as shown here.

Be sure to air seal all wall penetrations.

https://www.mnashp.org/guides

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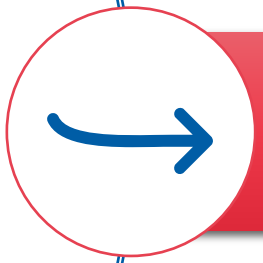
Installation Considerations – Key Takeaways

Be mindful of how outdoor unit & compressor placement can impact equipment operation and homeowner experience.



Ensure line set is routed so that it will not kink. Make sure the full line set length is insulated, including the flare nuts.

Utilize our best practices guide and other contractor resources to help guide high-quality installations.

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Example Walkthrough

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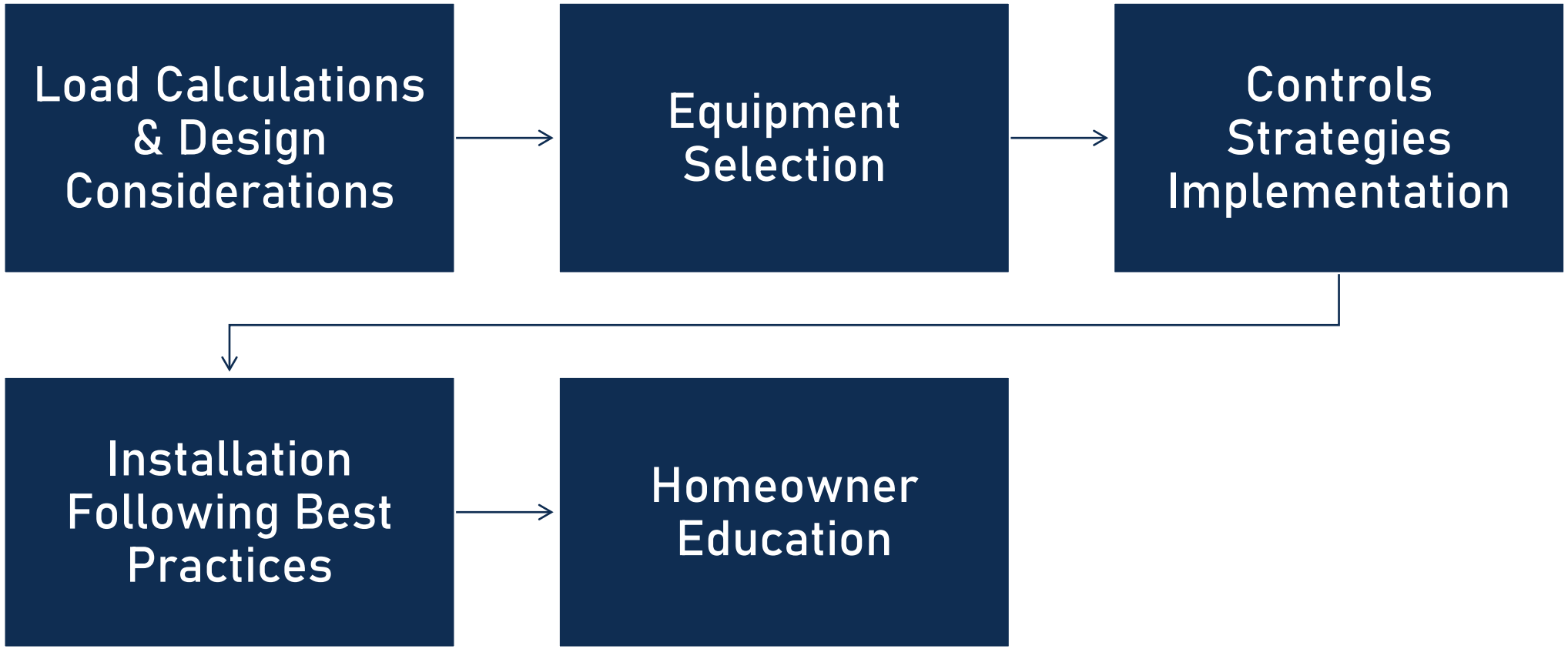
Process



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Scenario

- Home in Fergus Falls, MN
- Utility setup
  - Electric rate: $0.12/kWh
  - Propane rate: $2.30/gal
- Customer wants a dual-fuel cold climate heat pump and to still use their propane furnace as supplemental heat.
- Current AC sized for 3 tons; ductwork seems to be a bit small
  - How can this guide heat pump sizing?
- Envelope could be improved
  - What should be discussed with the customer?

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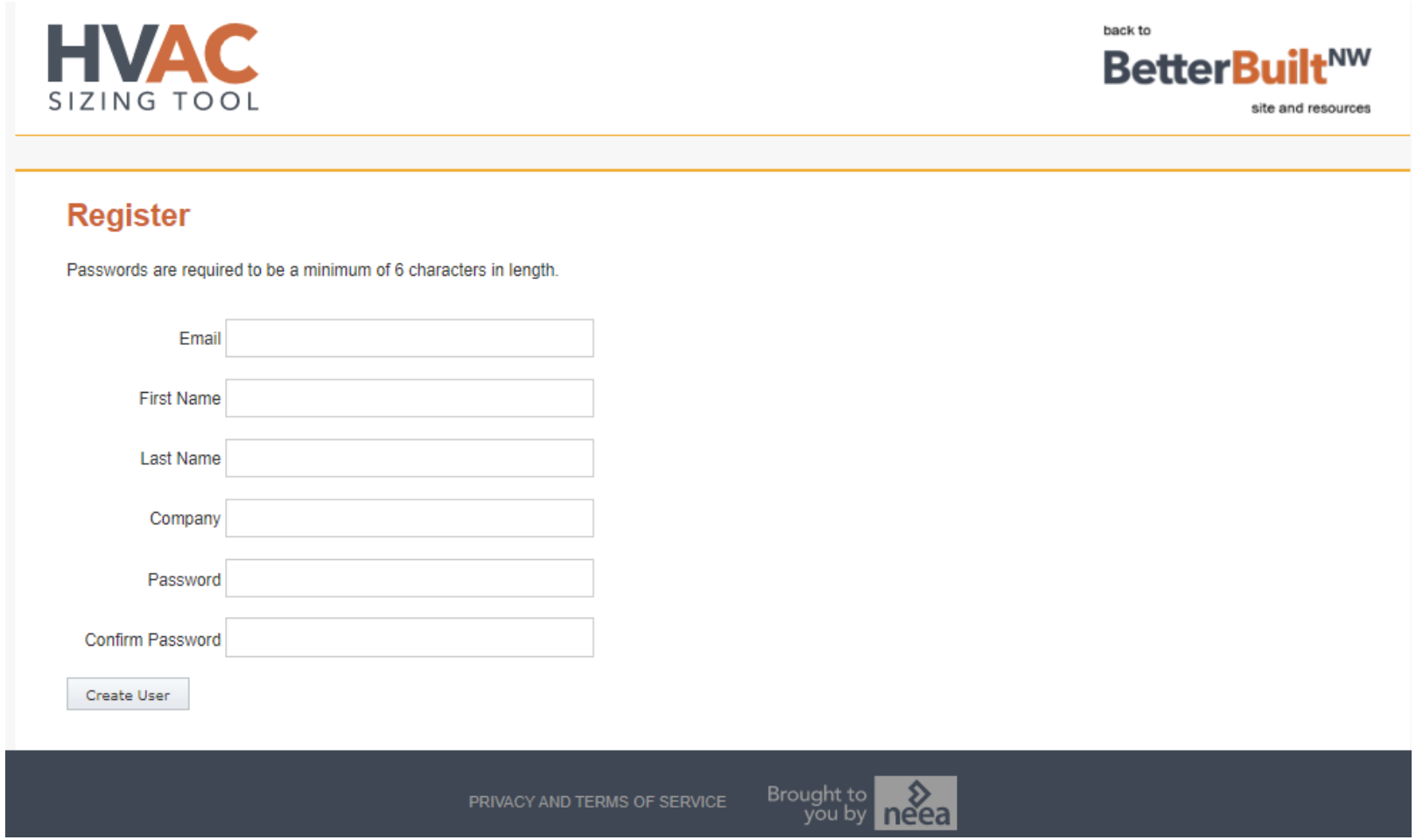
Free Sizing Tool online we are using today

Step 1: Sizing



https://hvac.betterbuiltnw.com/Account/Register.aspx

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Example House

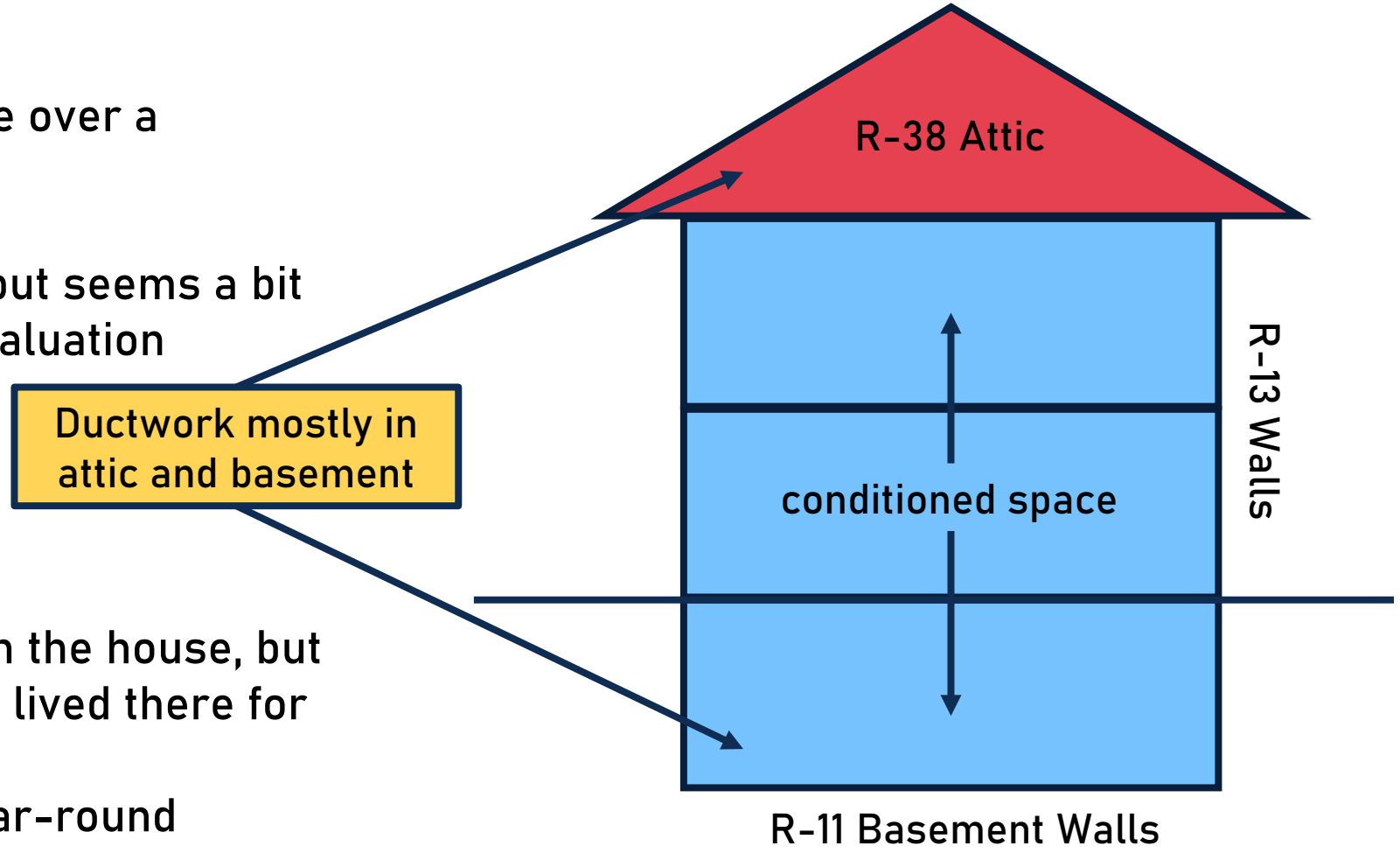
Step 1: Sizing

Specifications:

- 2250 sq ft, 2 story home over a conditioned basement
- Built in the early 1970s
- Ductwork is all metal, but seems a bit small and in need of evaluation

Homeowner Feedback

- AC doesn't keep up with the house, but homeowners have only lived there for two summers
- Comfort complaints year-round upstairs



Man J vs Rule of Thumb – One Ton per 400 sq ft

HVAC SIZING TOOL

Step 1: Sizing

Building

Conditioned Floor Area	2250	Floors Above Grade	2
Average Wall Height	8.5	Bedrooms	4

Default Insulation Level	2x6 insulated w/vinyl windows
Foundation Type	Conditioned Basement
Duct Location	Custom (enter details below)

Custom Duct Location

Attic %	35
Unconditioned Basement or Crawl Space %	0
Conditioned Area %	65

Direction Front Door (House Orientation)	West
Year Built	1970

Fergus Falls Example House

Site ID:	19723	Heating:	51,700 BTU/hr
Area:	2,250 ft²	Cooling:	16,200 BTU/hr
Climate:	Fergus Falls	Latent:	3,300 BTU/hr₇₄

Man J = 4.3 tons

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What did we learn about old school rules of thumb?

Step 1: Sizing

Manual J vs Rule of Thumb

Manual J = 4.3 tons

1 ton per 400 sq ft
2250 sq ft = 5.6 tons

Was the system oversized?

YES, by over a ton!

The square feet per ton you get from Manual J still gives you an oversized system, even when you do it correctly.

Mike MacFarland (owner of Energy Docs) says he finds it 20-40% too much capacity. David Butler (Optimal Building Systems LLC- retired) says 15%. In my own condo, for which I've measured AC runtimes for the past two years, I'm seeing about 75% - Allison Bailes III (Energy Vanguard).

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

Step 2: Equipment Selection

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

Product Type | Ducting Configuration | Brand | AHRI, Model, Unit | Heating Capacity 47°F Rated Btu/h | Heating Capacity 5°F Max Btu/h

All Product Typ | All Ducting Co | All Brands | AHRI, Model or Ur | 0 — 80000 | 0 — 80000

ENERGY STAR Certified

- ☐ ENERGY STAR V6.1
- ☐ ENERGY STAR V6.1 Cold Climate

Eligible for Federal Tax Credit

- ☐ North
- ☐ South

SEARCH THE LIST

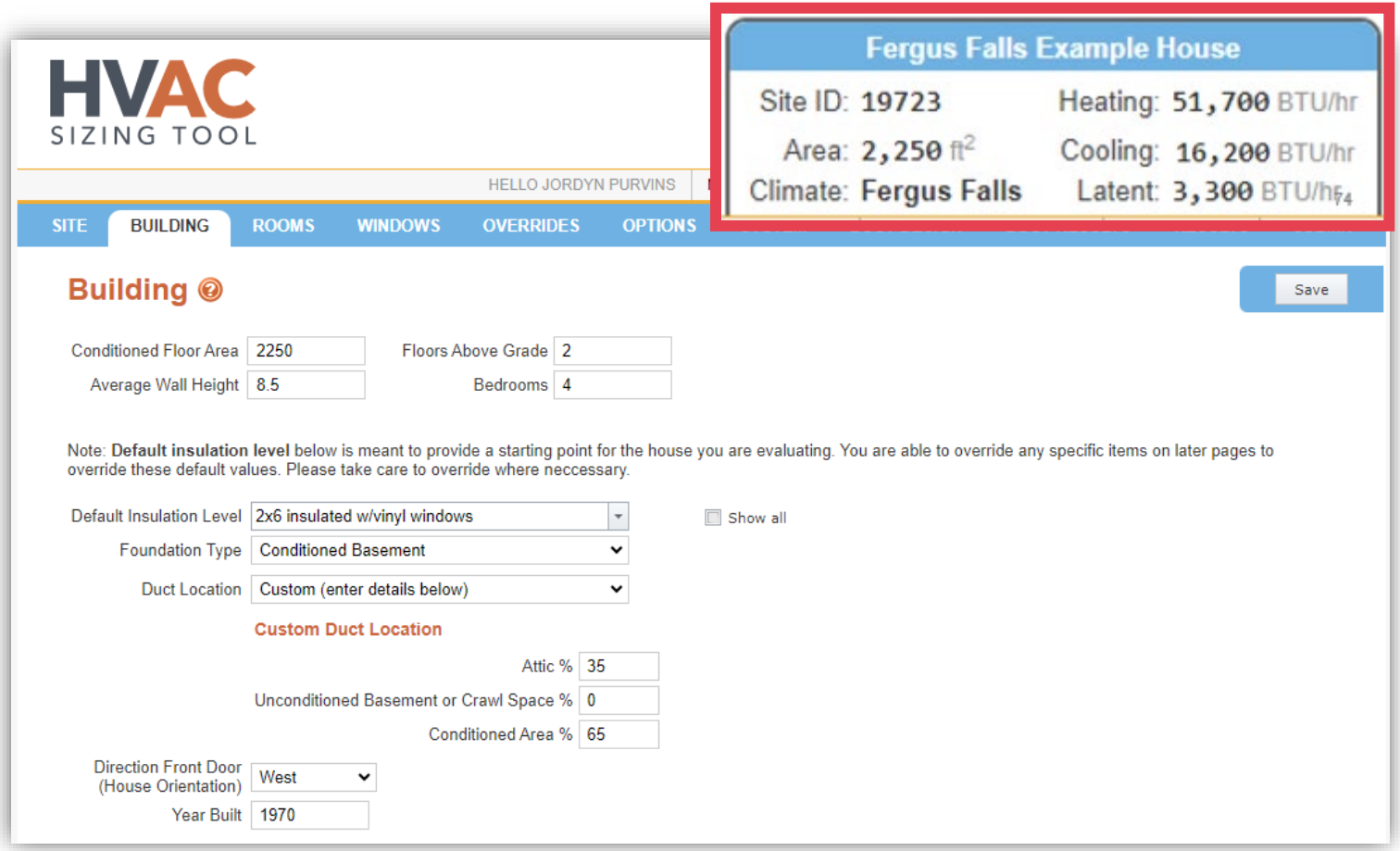
Advanced Search - Sizing for Heating

Advanced Search - Sizing for Heating User Guide

Example House

Step 2: Equipment Selection

Fergus Falls, MN
1970 construction
2250 sq ft
4 bedrooms
2 floors above grade
Conditioned basement
R-38 attic
R-13 walls
R-11 basement walls



What size system might you recommend with knowing JUST this information?

NEEP Tool – Data Input

Step 2: Equipment Selection

https://ashp.neep.org/#!/product/78771/7/25000/95/7500/0///0

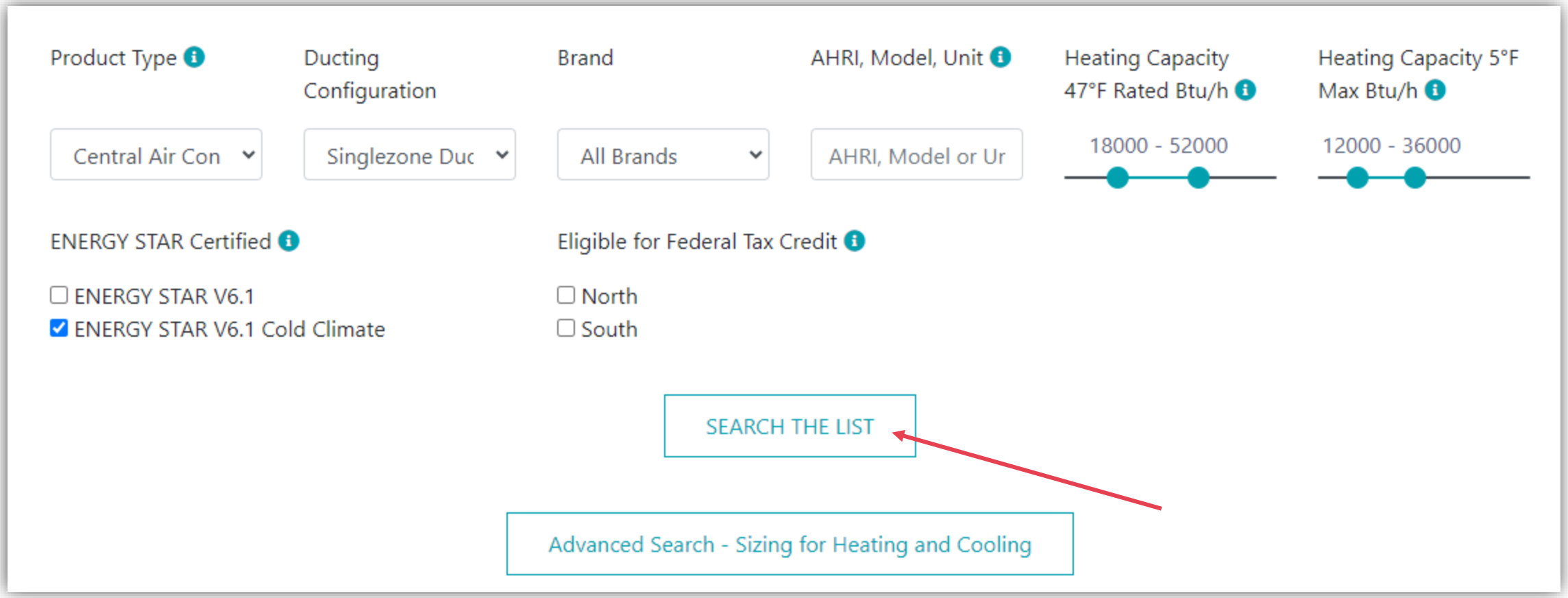
Product Type:	Central Air Conditioning Heat Pump (HP)
Ducting Configuration:	Singlezone Ducted, Centrally Ducted
Brand:	All Brands
AHRI, Model, Unit #:	N/A
Rated Heating Capacity @ 47F:	18,000 – 52,000 Btu/h
Max Heating Capacity @ 5F:	12,000 – 36,000 Btu/h

Specifying brand or searching for a few specific model #s to compare is a great way to narrow down the search results

☑ ENERGY STAR V6.1 Cold Climate

NEEP Tool – Data Input

Step 2: Equipment Selection



- Fill out the data fields to search for equipment
- We recommend being as specific as possible to narrow down search results – there's a lot of equipment listed!

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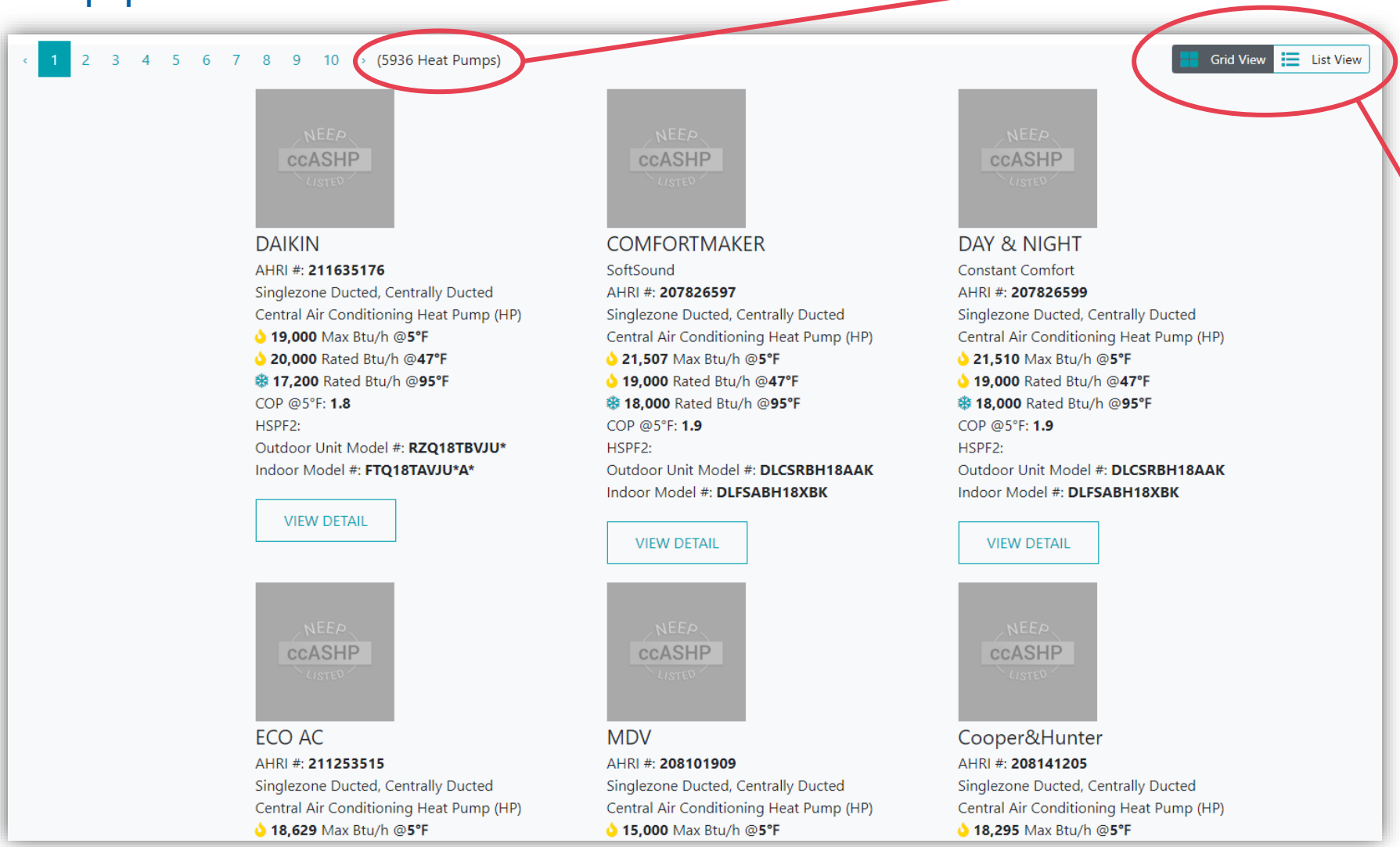
NEEP Tool – Search Results

Step 2: Equipment Selection

5936 Heat Pumps



- Defaults to 'Grid View'
- We recommend switching to 'List View' for easier scrolling, comparing, and filtering

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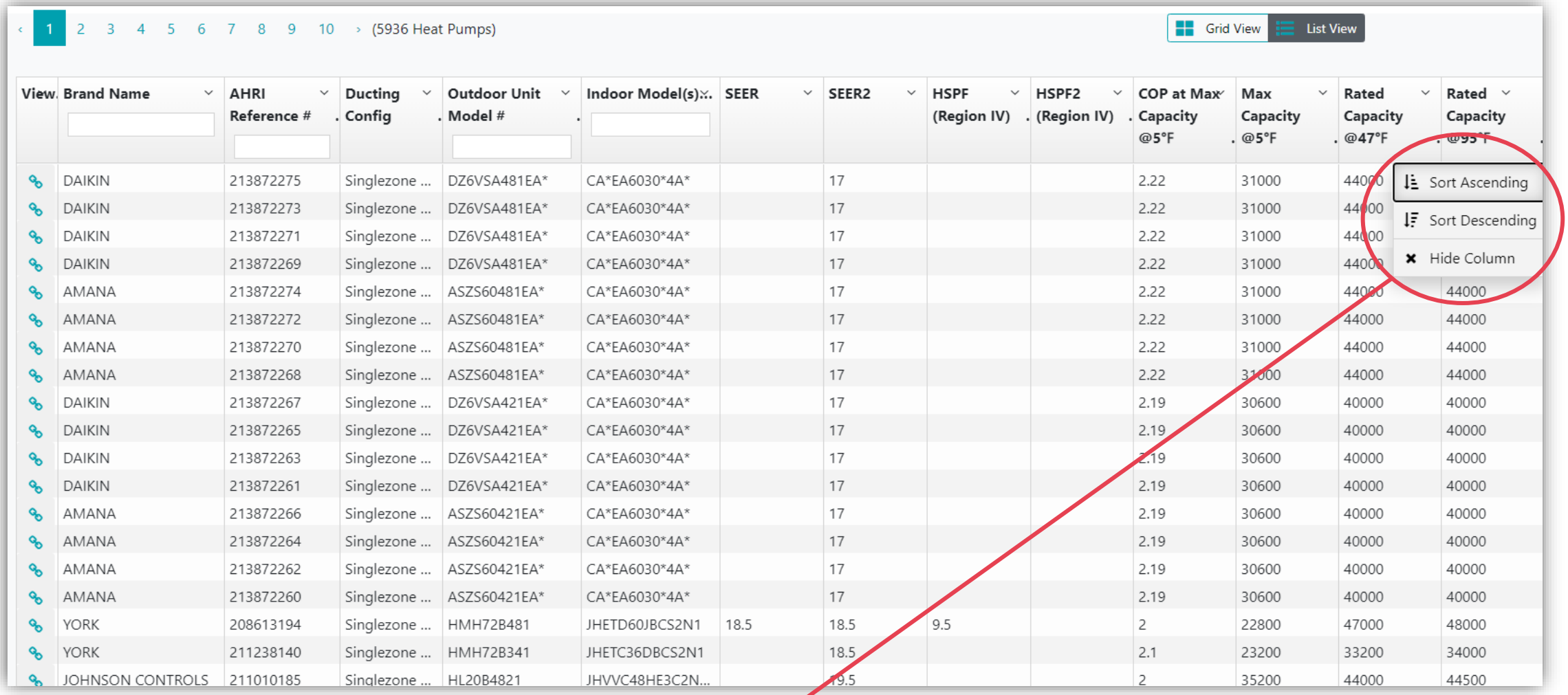
NEEP Tool – Search Results

Step 2: Equipment Selection



View	Brand Name	AHRI Reference #	Ducting Config	Outdoor Unit Model #	Indoor Model(s)	SEER	SEER2	HSPF (Region IV)	HSPF2 (Region IV)	COP at Max Capacity @5°F	Max Capacity @5°F	Rated Capacity @47°F	Rated Capacity @95°F
	DAIKIN	213872275	Singlezone ...	DZ6VSA481EA*	CA*EA6030*4A*		17			2.22	31000	44000	
	DAIKIN	213872273	Singlezone ...	DZ6VSA481EA*	CA*EA6030*4A*		17			2.22	31000	44000	
	DAIKIN	213872271	Singlezone ...	DZ6VSA481EA*	CA*EA6030*4A*		17			2.22	31000	44000	
	DAIKIN	213872269	Singlezone ...	DZ6VSA481EA*	CA*EA6030*4A*		17			2.22	31000	44000	
	AMANA	213872274	Singlezone ...	ASZS60481EA*	CA*EA6030*4A*		17			2.22	31000	44000	44000
	AMANA	213872272	Singlezone ...	ASZS60481EA*	CA*EA6030*4A*		17			2.22	31000	44000	44000
	AMANA	213872270	Singlezone ...	ASZS60481EA*	CA*EA6030*4A*		17			2.22	31000	44000	44000
	AMANA	213872268	Singlezone ...	ASZS60481EA*	CA*EA6030*4A*		17			2.22	31000	44000	44000
	DAIKIN	213872267	Singlezone ...	DZ6VSA421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	DAIKIN	213872265	Singlezone ...	DZ6VSA421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	DAIKIN	213872263	Singlezone ...	DZ6VSA421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	DAIKIN	213872261	Singlezone ...	DZ6VSA421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	AMANA	213872266	Singlezone ...	ASZS60421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	AMANA	213872264	Singlezone ...	ASZS60421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	AMANA	213872262	Singlezone ...	ASZS60421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	AMANA	213872260	Singlezone ...	ASZS60421EA*	CA*EA6030*4A*		17			2.19	30600	40000	40000
	YORK	208613194	Singlezone ...	HMH72B481	JHETD60JBCS2N1	18.5	18.5	9.5		2	22800	47000	48000
	YORK	211238140	Singlezone ...	HMH72B341	JHETC36DBCS2N1		18.5			2.1	23200	33200	34000
	JOHNSON CONTROLS	211010185	Singlezone ...	HL20B4821	JHVVC48HE3C2N...		19.5			2	35200	44000	44500

- For each field/column, you can sort by ascending order, descending order, or choose to hide the column to make the search process easier

NEEP Tool – Equipment Page

Step 2: Equipment Selection

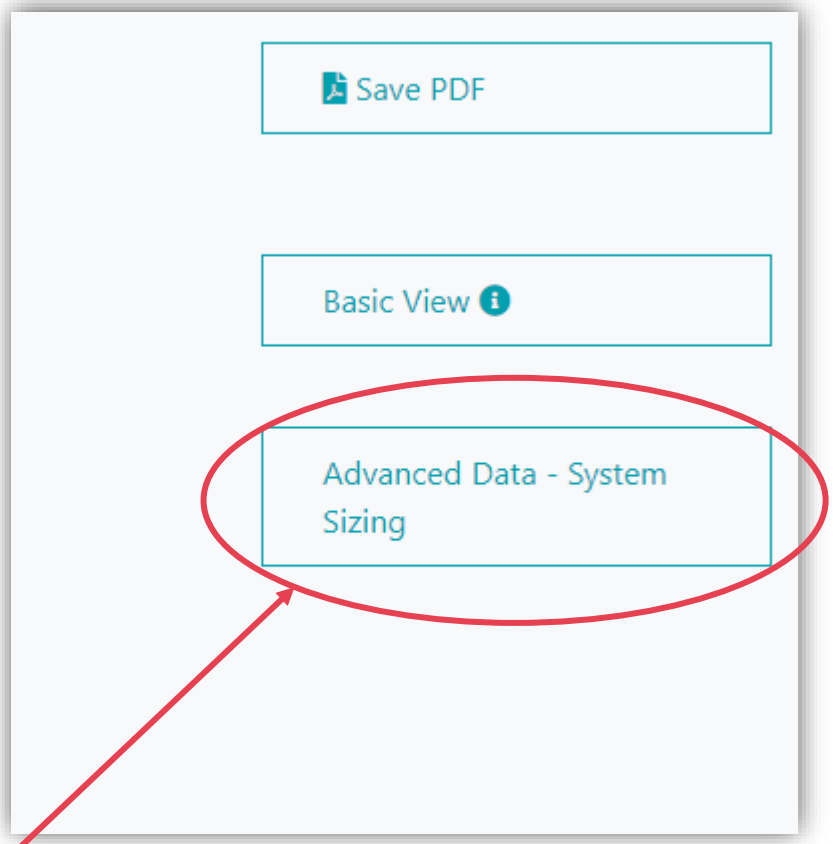
Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Cooling	95°F	80°F	Btu/h	11,000	23,400	31,000
			kW	0.72	2.36	4.04
			COP	4.48	2.91	2.25
Cooling	82°F	80°F	Btu/h	12,200	-	34,000
			kW	0.67	-	3.76
			COP	5.34	-	2.65
Heating	47°F	70°F	Btu/h	11,500	27,400	35,000
			kW	0.91	2.47	3.73
			COP	3.7	3.25	2.75
Heating	17°F	70°F	Btu/h	6,400	19,400	25,500
			kW	0.82	2.23	3.31
			COP	2.29	2.55	2.26
Heating	5°F	70°F	Btu/h	5,400	20,800	20,800
			kW	0.83	3.1	3.1
			COP	1.91	1.97	1.97
Heating	-3°F	70°F	Btu/h	5,400	-	18,800
			kW	0.93	-	2.85
			COP	1.7	-	1.93

- Information tables also include efficiency ratings, ENERGY STAR and regional tax credit eligibility, capacity maintenance, etc.

NEEP Tool – System Sizing

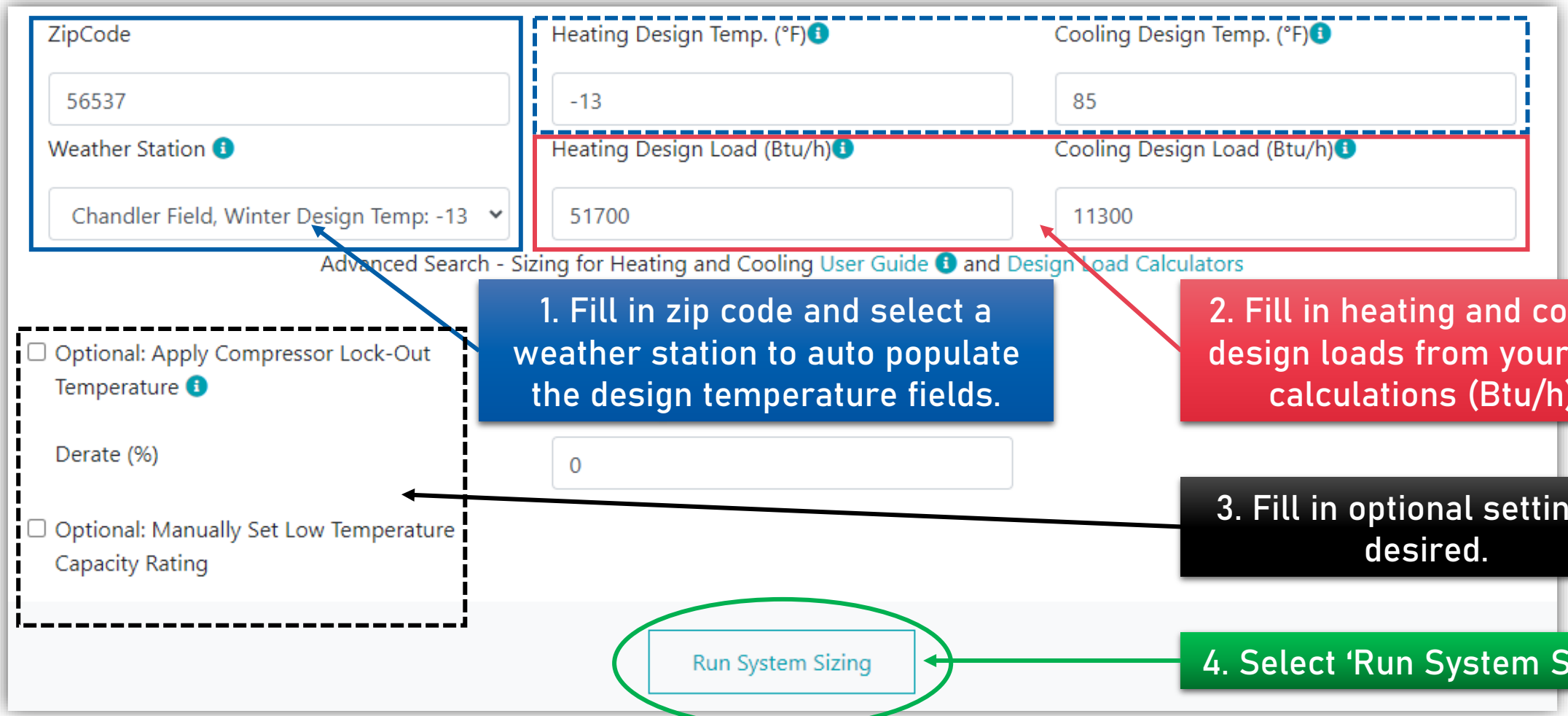
Step 2: Equipment Selection



- At the top of the equipment page to the right of the equipment overview, you can select the 'Advanced Data – System Sizing' button.

NEEP Tool – System Sizing

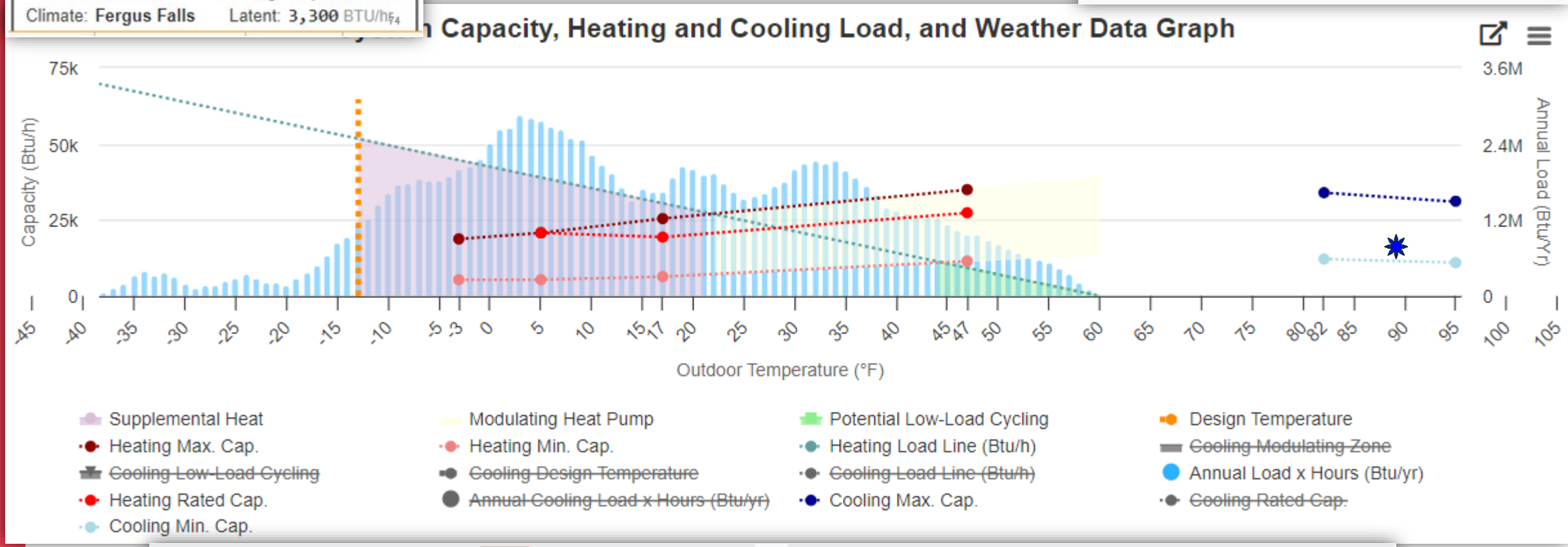
Step 2: Equipment Selection



2 Ton System

Fergus Falls Example House			
Site ID:	19723	Heating:	51,700 BTU/hr
Area:	2,250 ft²	Cooling:	16,200 BTU/hr
Climate:	Fergus Falls	Latent:	3,300 BTU/hr

- Maximum Heating Capacity (Btu/h) @5°F: **20,800**
- Rated Heating Capacity (Btu/h) @47°F: **27,400**
- Rated Cooling Capacity (Btu/h) @95°F: **23,400**



Capacity Balance Point (°F)	22
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)	129.3
Percent Annual Heating Load Served	38.3%

Annual Btu's Covered by Supplemental Heat (MMBtu)	79.8
Hours Requiring Supplemental Heat	2,014
Percent Hours Requiring Supplemental Heat	32.3%
Percent Annual Load Modulating	72.0%
Percent Annual Load with Low-Load Cycling	7.9%

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rg/

Thermostat Selection

Step 3: Controls Strategies

- Dual fuel compatibility is the most important consideration when selecting a thermostat.

- Proprietary vs third-party thermostats
  - Heat pumps can achieve the best possible performance with proprietary thermostats, especially in the case of communicating, variable speed equipment.
  - Third-party staged thermostats can limit the capabilities of equipment operation, resulting in loss of efficiency and anticipated cost savings.

- Always engage your distributor or manufacturer's rep for guidance on thermostat selection, especially if the customer will only agree to a third-party product.

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Customer Priorities

Step 3: Controls Strategies

- Customer cares most about comfort.
- They are also expecting to achieve cost savings by replacing their AC with a heat pump.

- Customer wants the ecobee thermostat.

- How would you approach the conversation of thermostat selection?
  - Third-party vs proprietary
  - Which features does the customer want?

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Economic Balance Point Calculation

Step 3: Controls Strategies

BeCOP = Breakeven Coefficient of Performance

$$BeCOP = \frac{(E \times C \times Ef)}{G}$$

E = $/kWh

C = kWh/gal propane

Ef = Efficiency of furnace

G = $/gal propane

Example House Calculation

$$BeCOP = \frac{(0.12 \times 27 \times 0.80)}{2.30}$$

BeCOP = 1.1

E = $0.12/kWh

C = 27 kWh/gal

Ef = 0.80 (80% AFUE)

G = $2.30/gal

Economic Balance Point Calculation

Step 3: Controls Strategies

BeCOP = 1.1

- Look at the Performance Specs chart to identify the Rated COP at different temperatures.
- You can estimate the economic balance point depending on where the BeCOP falls on the chart.
- We can estimate 0°F.
- Economic Balance Point is very low, which is to be expected with propane systems.

- A natural gas system with a rate of $1.04/therm gives us a BeCOP of 2.7.
- The economic balance point falls between 17°F and 47°F, so the capacity balance point of 22°F is likely to be most advantageous economically as well.

Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Cooling	95°F	80°F	Btu/h	11,000	23,400	31,000
			kW	0.72	2.36	4.04
			COP	4.48	2.91	2.25
Cooling	82°F	80°F	Btu/h	12,200	-	34,000
			kW	0.67	-	3.76
			COP	5.34	-	2.65
Heating	47°F	70°F	Btu/h	11,500	27,400	35,000
			kW	0.91	2.47	3.73
			COP	3.7	3.25	2.75
Heating	17°F	70°F	Btu/h	6,400	19,400	25,500
			kW	0.82	2.23	3.31
			COP	2.29	2.55	2.26
Heating	5°F	70°F	Btu/h	5,400	20,800	20,800
			kW	0.83	3.1	3.1
			COP	1.91	1.97	1.97
Heating	-3°F	70°F	Btu/h	5,400	-	18,800
			kW	0.93	-	2.85
			COP	1.7	-	1.93

Switchover Temperature Selection

- Thermal/Capacity balance point: 22F
- Economic balance point: 0F
- Comfort balance point: ~23-25F

- What switchover temperature would you select?

- Which other controls settings would you implement?

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Installation Considerations

- Stand height will not fully raise unit above the snow line.
  - What should you do?
- AC unit was previously placed next to the primary bedroom window.
  - How should you approach where to install the heat pump?
- The new equipment location is near a section of the house that does not have a gutter, creating a drip line risk.
  - How can you ensure the equipment will be protected from moisture freeze?

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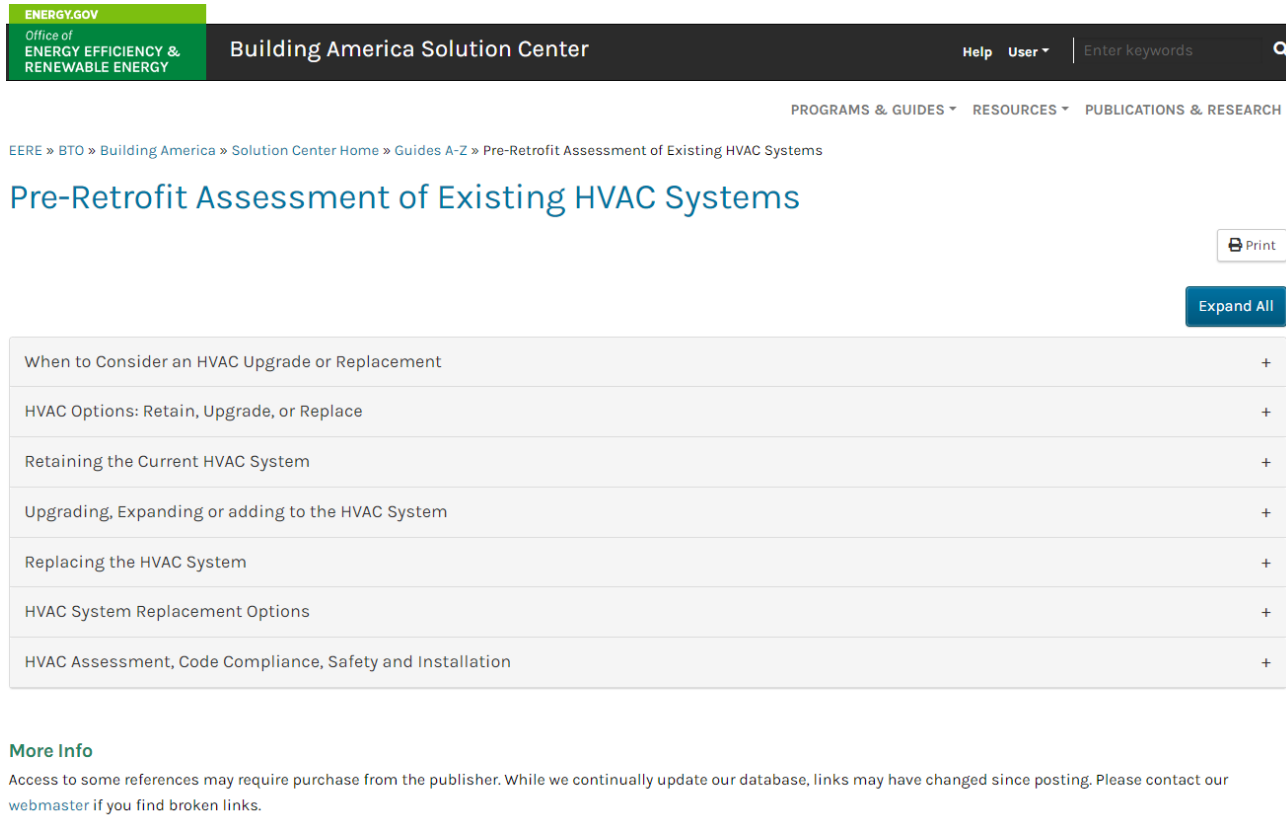
Sales and Comfort Consult

- Data collection tool used?
- Can you convert to an installation checklist?
- Does your team have internal QC policies?



https://basc.pnnl.gov/existing-homes/anytime-equipment-upgrades

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Installers and Technicians

- Does your team have internal QC policies?
- Do you have a commissioning/start up sheet that you use?
- Do you track call backs, incentive QA fails, or homeowner challenges?

https://basc.pnnl.gov/home-improvement-expert/checklists/heat-pump-replacement

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Home Improvement Expert™ Checklist

Heat Pump Replacement

This U.S. Department of Energy checklist includes important specifications that can contribute to a complete and quality installation. All work shall comply with these specifications, all relevant codes and standards, and all manufacturer installation instructions. The contractor shall check each box on the checklist below and sign and date at the bottom to certify the work is completed.

	PREPARATION
☐	All exposed ducts (e.g., attic, basement, and crawlspace) shall be inspected; all damaged or disconnected ducts shall be repaired or replaced, and all visible leaks shall be sealed with UL 181 tape and/or mastic.
☐	A room-by-room load calculation shall be performed in accordance with the Air-Conditioning Contractors of America [ACCA] Manual J.
☐	The heat pump selected shall be ENERGY STAR certified and sized in accordance with ACCA Manual S based on ACCA Manual J load calculation results.
☐	The system shall be evaluated to determine if the supply and return air flows are balanced and if ducts are properly sized. Recommendations shall be made to the homeowner if the ducts are not the right size.
	INSTALLATION
☐	The heat pump shall be installed in accordance with ANSI/ACCA Standard 5 HVAC Quality Installation Specifications.
☐	The air filter shall be replaced with a MERV 8 or higher filter selected for appropriate air flow across the coil.
☐	If the air filter is installed in a filter media box attached to the air handler, the access panel for the filter should be fitted with a flexible, air-tight gasket to prevent air leakage.
☐	Where a new thermostat location is provided, it shall be located on an interior wall away from heating or cooling registers, appliances, lighting fixtures, exterior doors, skylights, windows, and areas that receive direct sunlight or drafts.
	COMMISSIONING
☐	Proper refrigerant charge shall be verified in accordance with the manufacturer's instructions.
☐	Pressure balance testing (pressure pan and/or flow hood) for proper room-to-room air flow shall be performed and adjustments shall be made to address any imbalances.
☐	Air flow across the coil shall be tested following procedures approved by ANSI/ACCA Standard 5 QI-2015 to verify it is within the CFM range specified by the equipment manufacturer. If it is not, adjustments shall be made as required.
☐	The home shall be inspected for the presence of a whole-house ventilation system. If one is present, the actual air flow shall be tested and verified to meet or exceed a target ventilation rate based on house size as follows: 50 cfm for up to 1,500 ft², 70 cfm for 1,501 to 2,500 ft², and 100 cfm over 2,500 ft², per ASHRAE 62.2-2013. Recommendations shall be made to the homeowner for either installing a new whole-house ventilation system compliant with the target rate if one is not present, or repairing an existing system to be compliant with the target rate if airflow is not adequate.

I hereby certify that, to the best of my knowledge and ability, all checked items on the above checklist have been accomplished as part of completion of this home upgrade.

Contractor Signature: _____ Date: _____

Contracting Organization: _____

Summary & Closing

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Summary

1. The business of heat pump installations is growing!
2. Research shows that heat pumps work in Minnesota.
3. Accurate sizing is essential for a quality installation.
4. Envelope and ductwork assessments are important and need to be considered to ensure full system compatibility.
5. Sizing, design, and selection all depend on the application.
6. Controls strategy implementation can make or break how a system will function.
7. It is critical to educate the homeowner!

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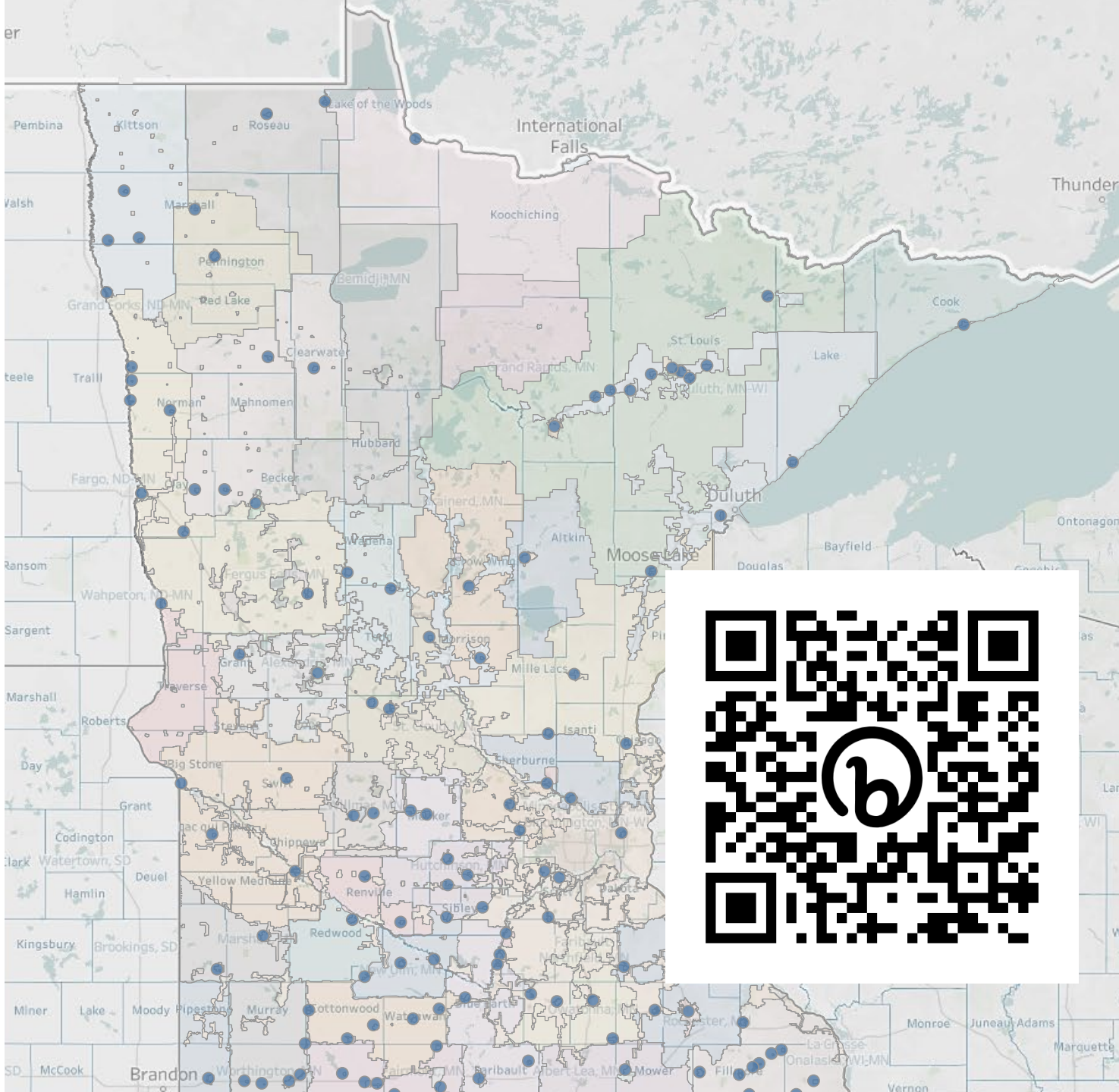
Incentives and Financing Resources

- Updates and information on federal and state incentives
- Utility rebates
  - Interactive map
  - Downloadable database
- Loan options beyond in-house financing products

https://www.mnashp.org/incentives-financing



Contractor Resources

- Product lists and specifications
- Interactive cost of heat comparison tool
- Load calculation tools
- Sizing and selection resources
- Best practices guide

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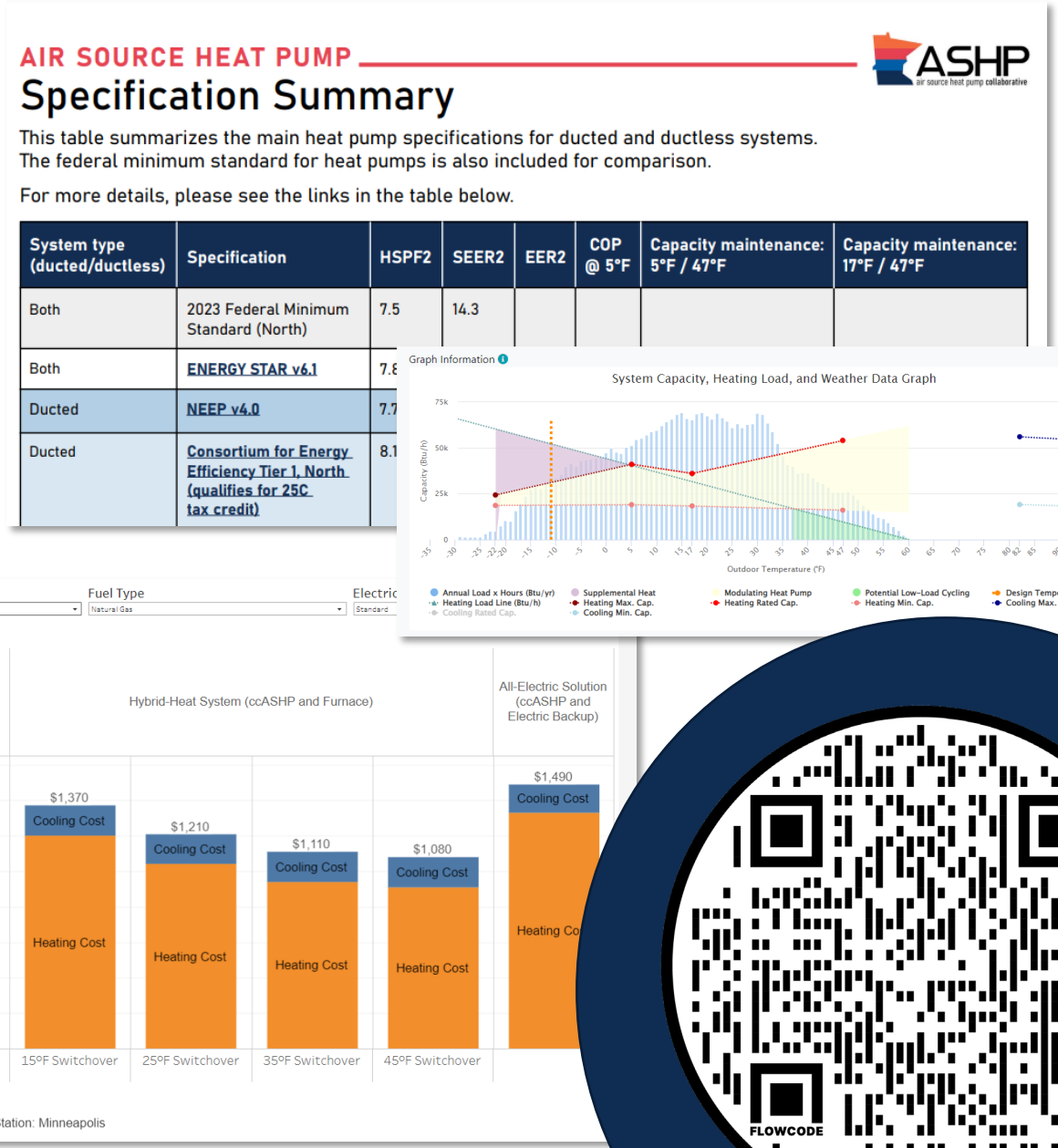
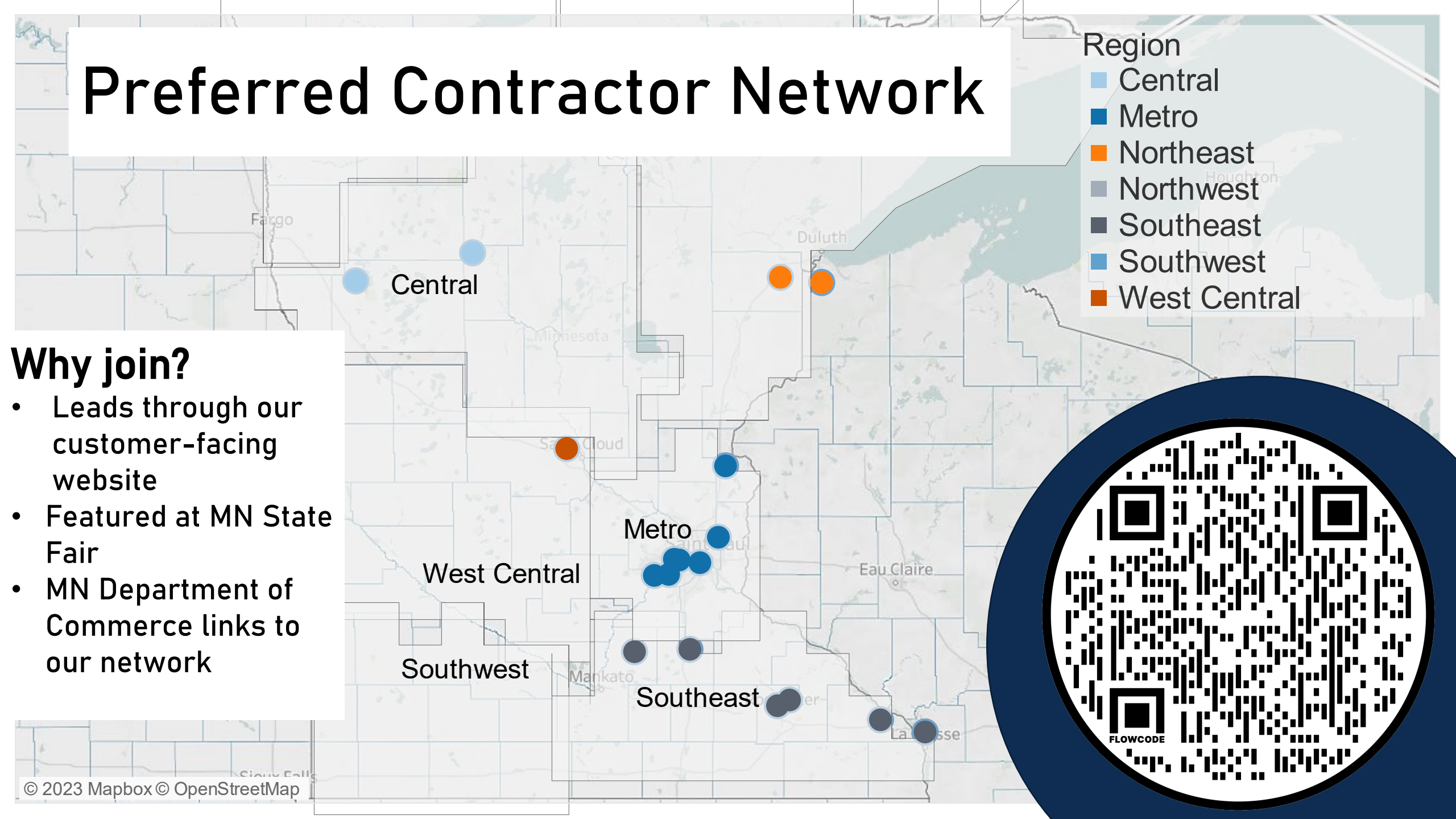


Preferred Contractor Network



Why join?

- Leads through our customer-facing website
- Featured at MN State Fair
- MN Department of Commerce links to our network

FLOWCODE

Next Steps for Contractors

Practice installations at employee homes to gain experience with the technology

Attend ongoing distributor and manufacturer trainings

Leverage and stack financial incentives and lending products

Sign up for our newsletter for updates in the market

mnashp.org

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Reach out to our team with questions!

Thank you!

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