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

- Building Performance Institute (BPI)
- 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 home?

Discussion goals

- ASHP potential in MN
- Incentives & financing
- ASHP field research results
- Load calculations
- Ductwork & envelope assessment
- Sizing and equipment selection
- ASHP application types
- Controls strategies and other 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.

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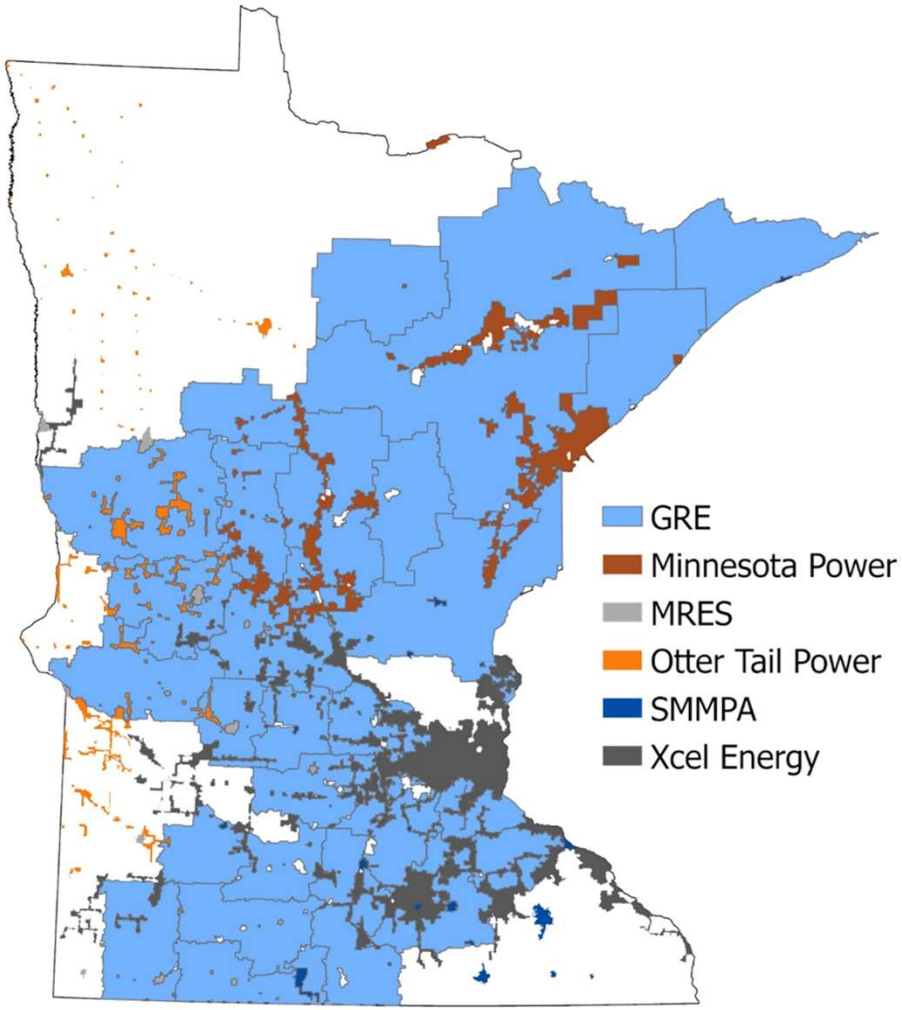
Center for Energy and Environment

MN ASHP Collaborative

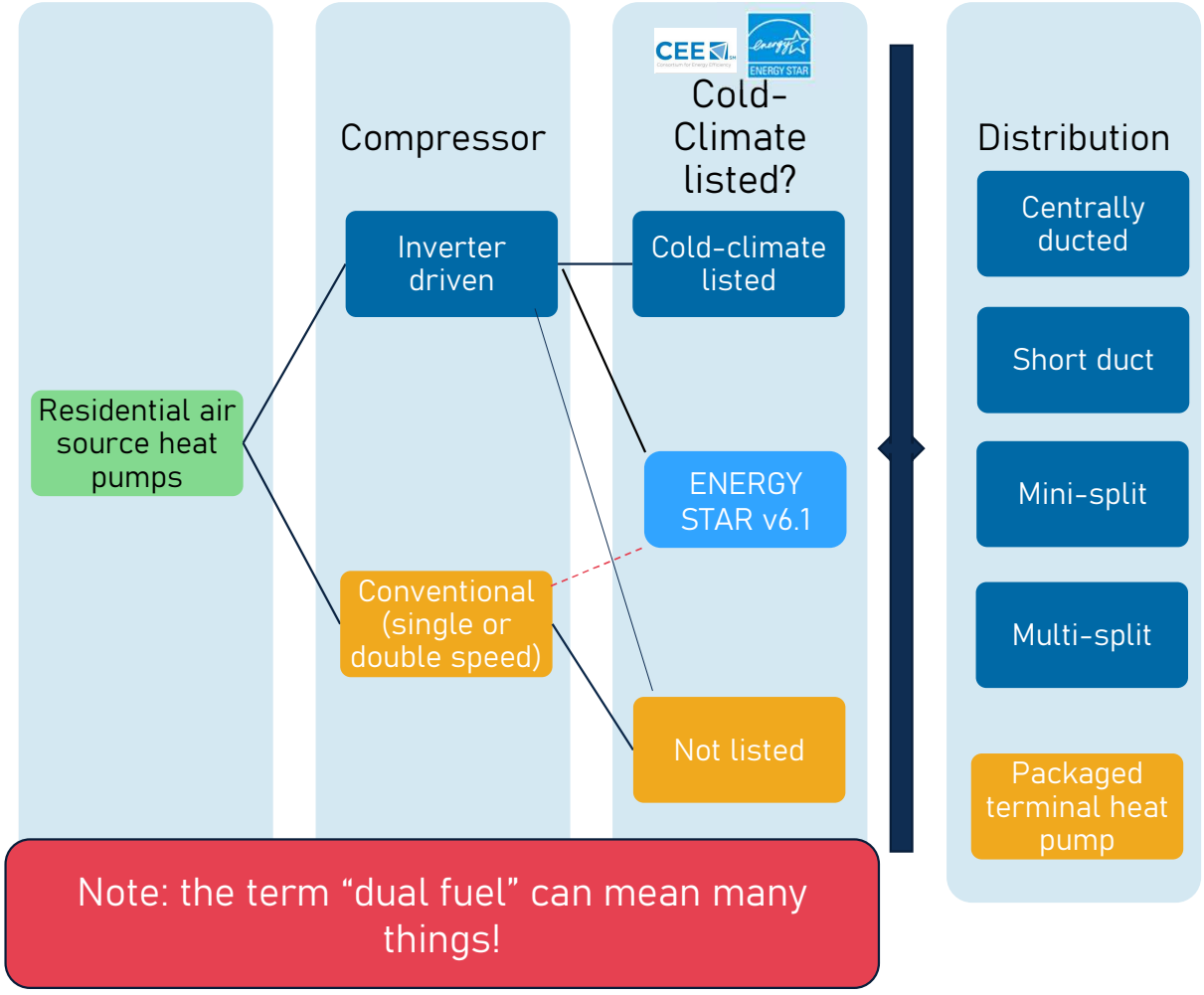


- Launched in 2019
- Investor-owned, cooperative, and municipal utilities contribute funding
- Mission to make air source heat pumps the first choice for consumers when cooling and heating their homes
- Supportive of dual fuel approaches to maximize customer and utility benefits

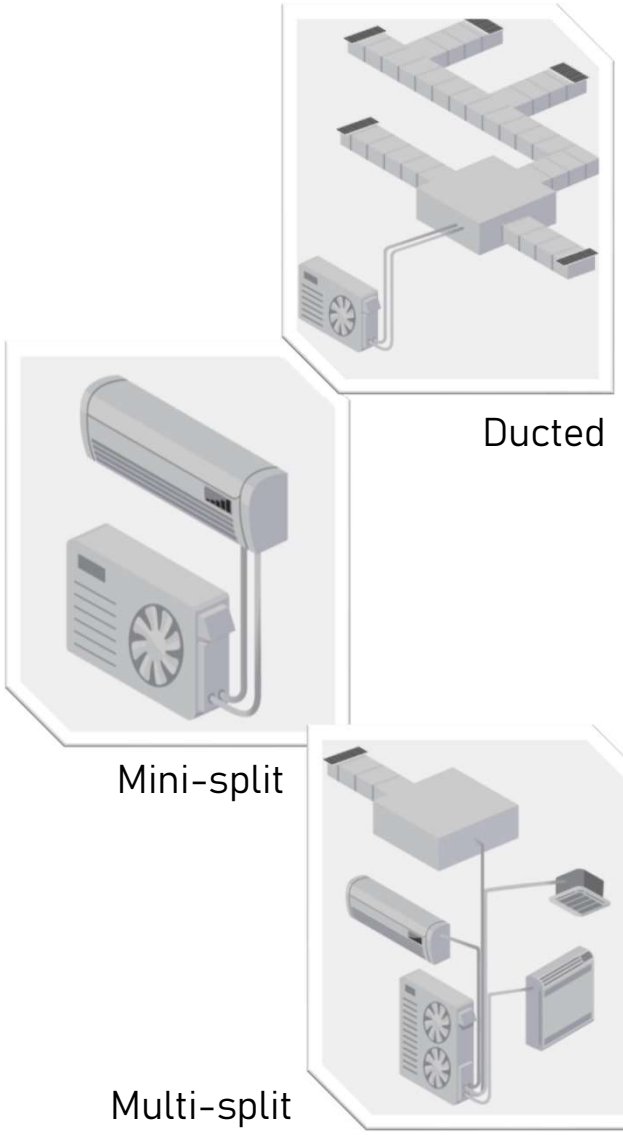
Minnesota Energy Resources
CenterPoint Energy
Great River Energy
Missouri River Energy Services
Southern Minnesota Municipal Power Agency
Otter Tail Power Company
Xcel Energy
Minnesota Power

Level Setting Terminology

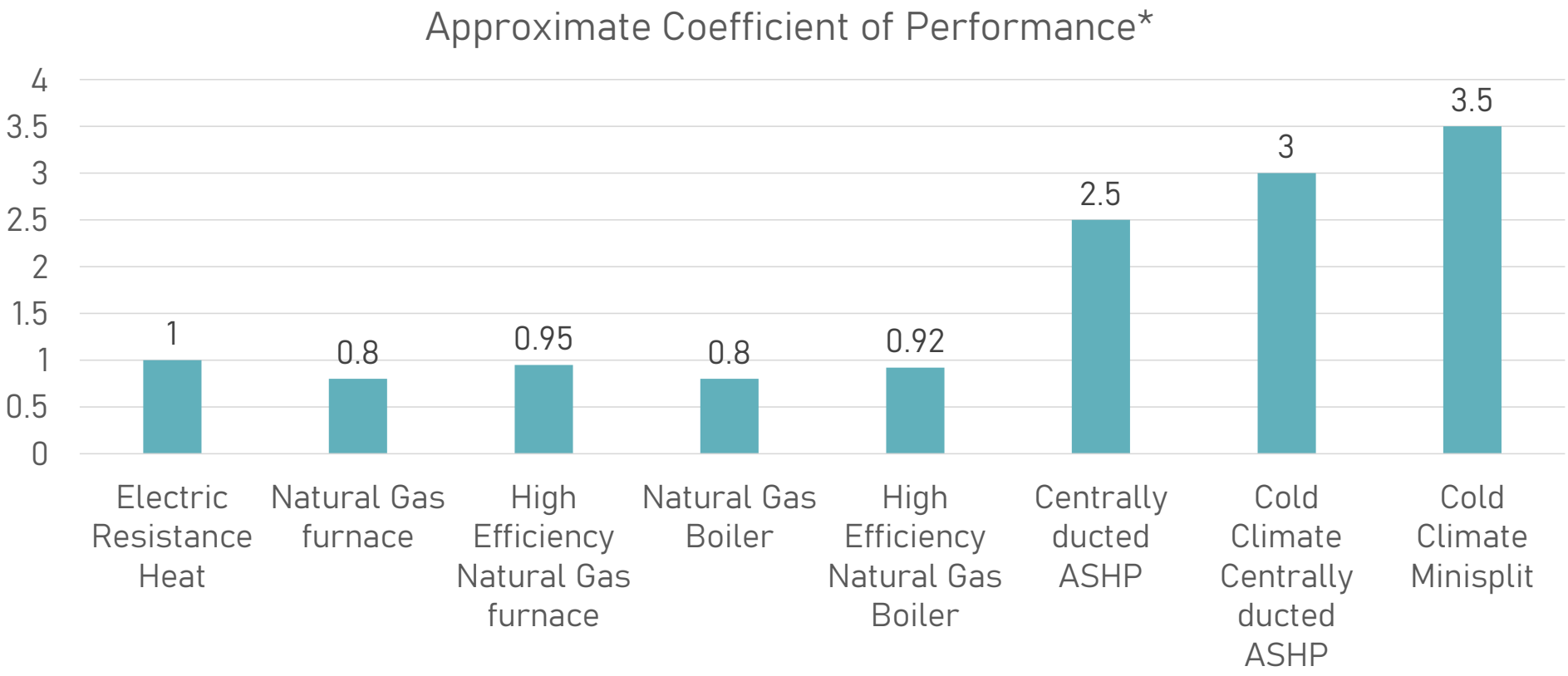
Heat Pump Taxonomy



Note: the term “dual fuel” can mean many things!



Comparing system types using Coefficient of Performance (COP)



**Note – Natural Gas appliances don't use COP as do Heat Pumps, but AFUE is used as a proxy due to the same scale as COP*

Broad Benefits of ASHPs

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ASHP Benefits – Big Picture

- Heating and cooling all in one system
- Fuel choice flexibility and resilience
- Improved comfort
- Heating and cooling operational cost savings
- Rebates and incentives
- Reduced carbon emissions

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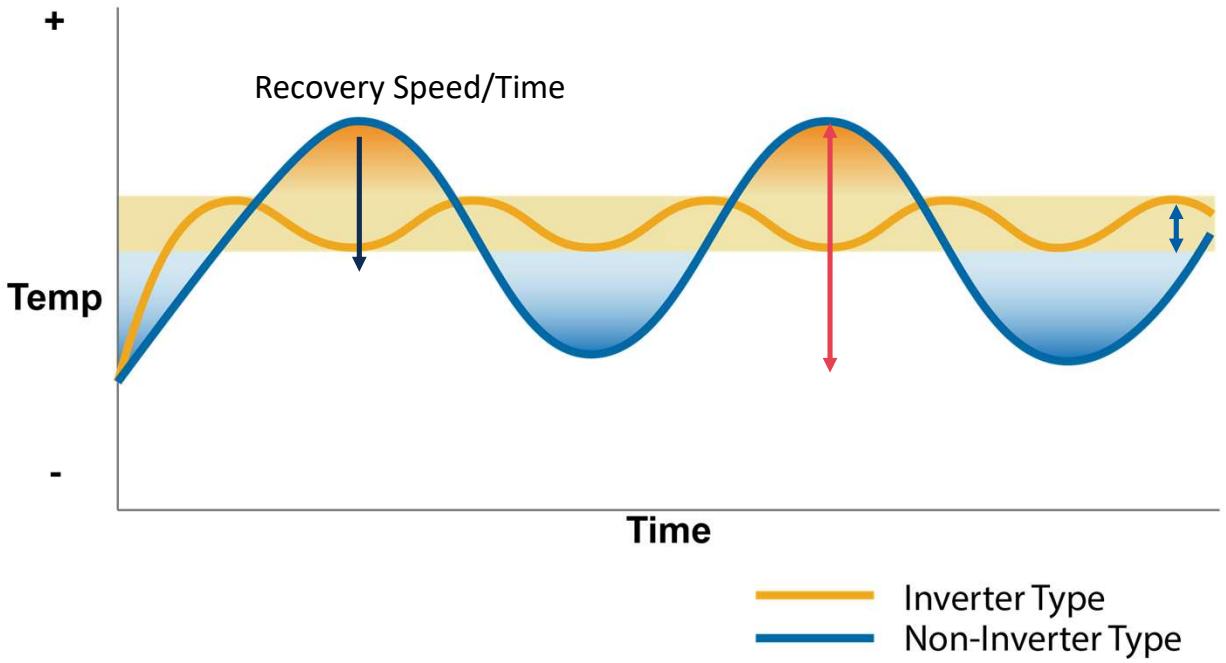
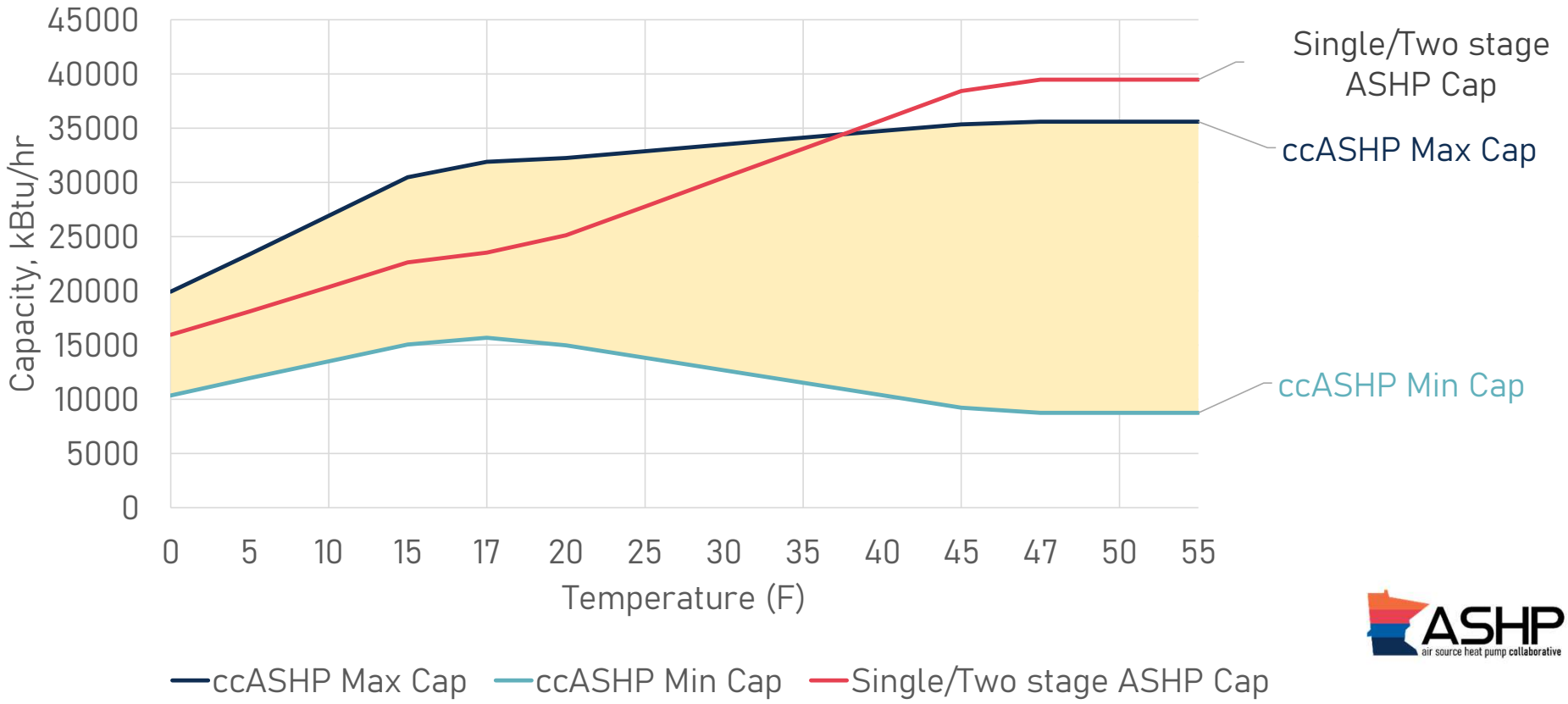
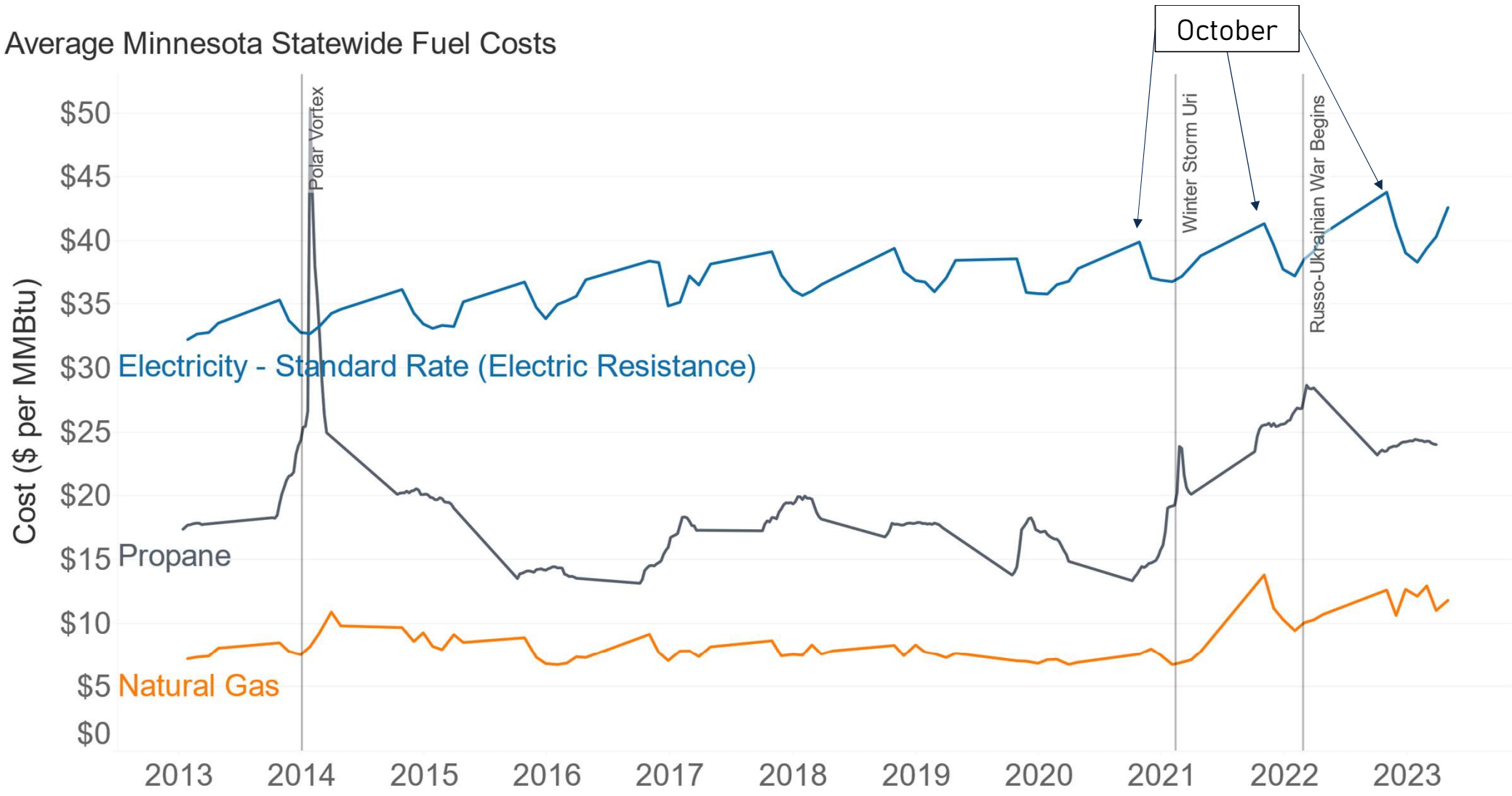
How Modulation Helps - Control



- More control
- Less waste
- Improved comfort

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



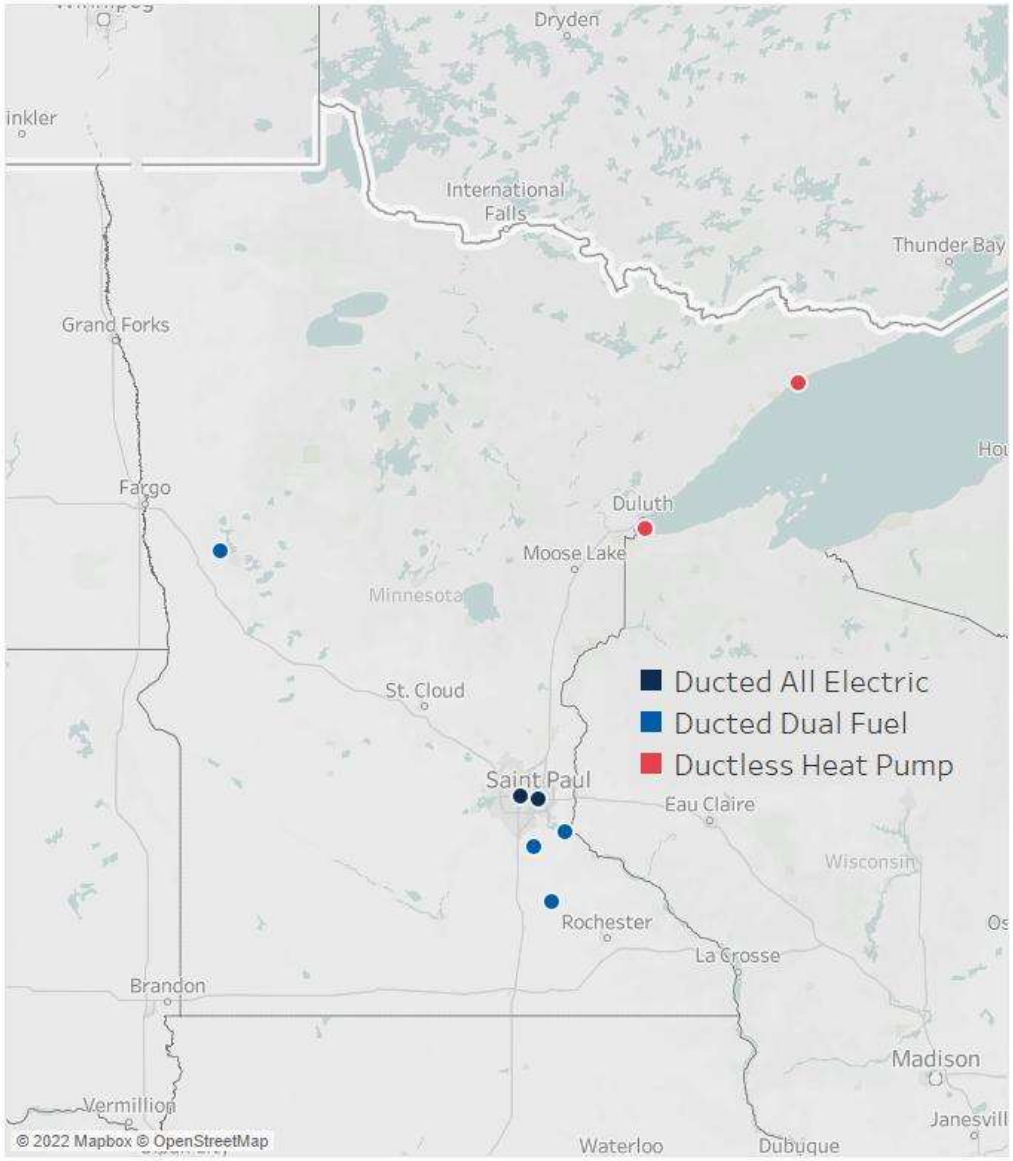


Data source: Energy Information Administration. Propane data are weekly values. Electricity and gas data are monthly values. May through September months excluded (shown are Oct - April) with the exception or propane, which is available through March.

Do ASHPs work well in cold climates?

CEE research example

- **Field Study (2015-2017)**
  - 8 ccASHPs in a variety of MN residences
    - 6 centrally ducted systems
    - 2 ductless mini-split systems
  - Monitor installed field performance of ASHP & backup
- **Each site had detailed data collection**



CEE's field research results

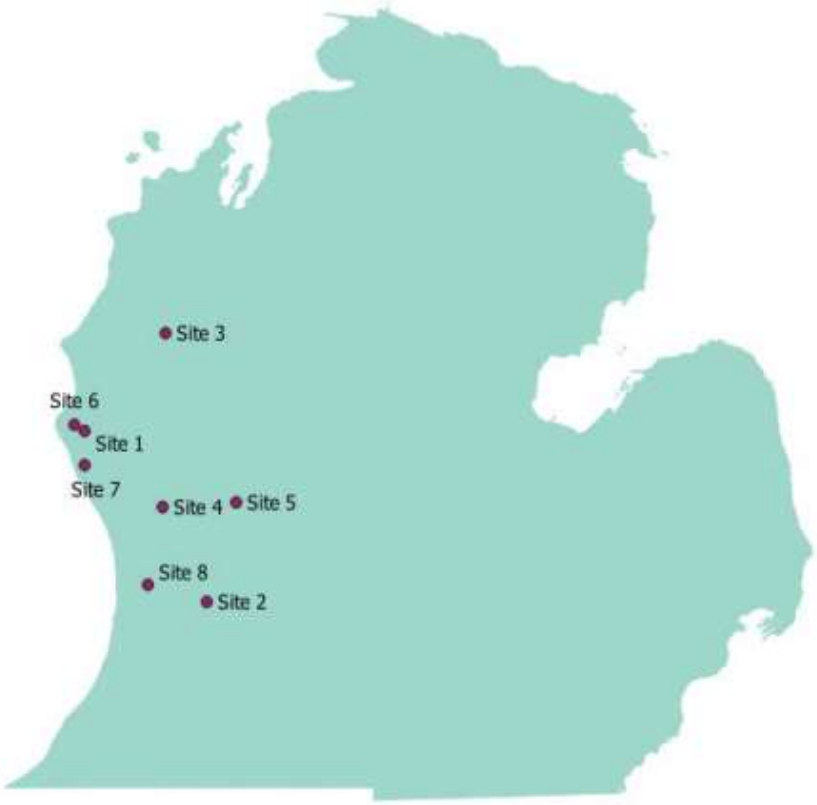
- Significant savings for replacing propane and electric resistance

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

- Systems were able to meet home heating loads at 10°F
- New generation systems can operate as low as -20°F
  (efficiently as low as -13°F)

Slipstream research example

- **Field Study (2019)**
  - 8 centrally ducted ASHPs installed in Michigan
    - 4 variable-speed
    - 2 multi-speed
    - 2 single-speed
  - Monitor installed field performance of ASHP & propane backup
- **Each site had detailed data collection**
- **Homeowner survey was completed**



Slipstream field research results

- Similar savings results to earlier CEE field study

Annual Cost of Operation		Annual Cost Savings		
Baseline	ASHP	Total	Total (% over baseline)	Propane Reduction
$2,033	$1,453	$579	28%	53%

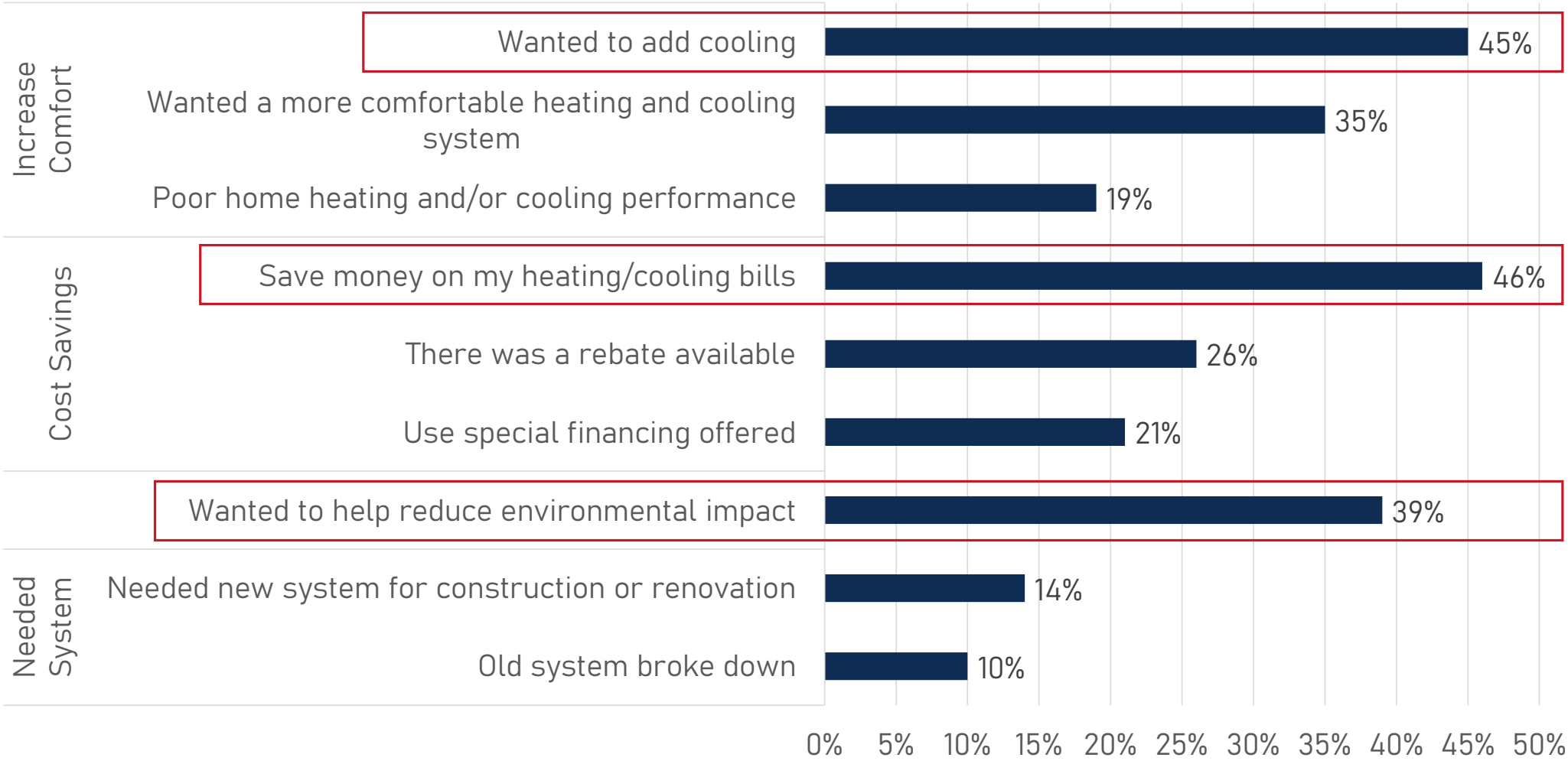
- 7/8 customers were satisfied with the ASHP
- Benefits reported
  - Improved comfort
  - Reduced propane use and fuel flexibility
- Primary drawbacks
  - Outdoor unit noise and increased electric bills

https://slipstreaminc.org/sites/default/files/documents/publications/dual-fuel-air-source-heat-pump-pilot.pdf

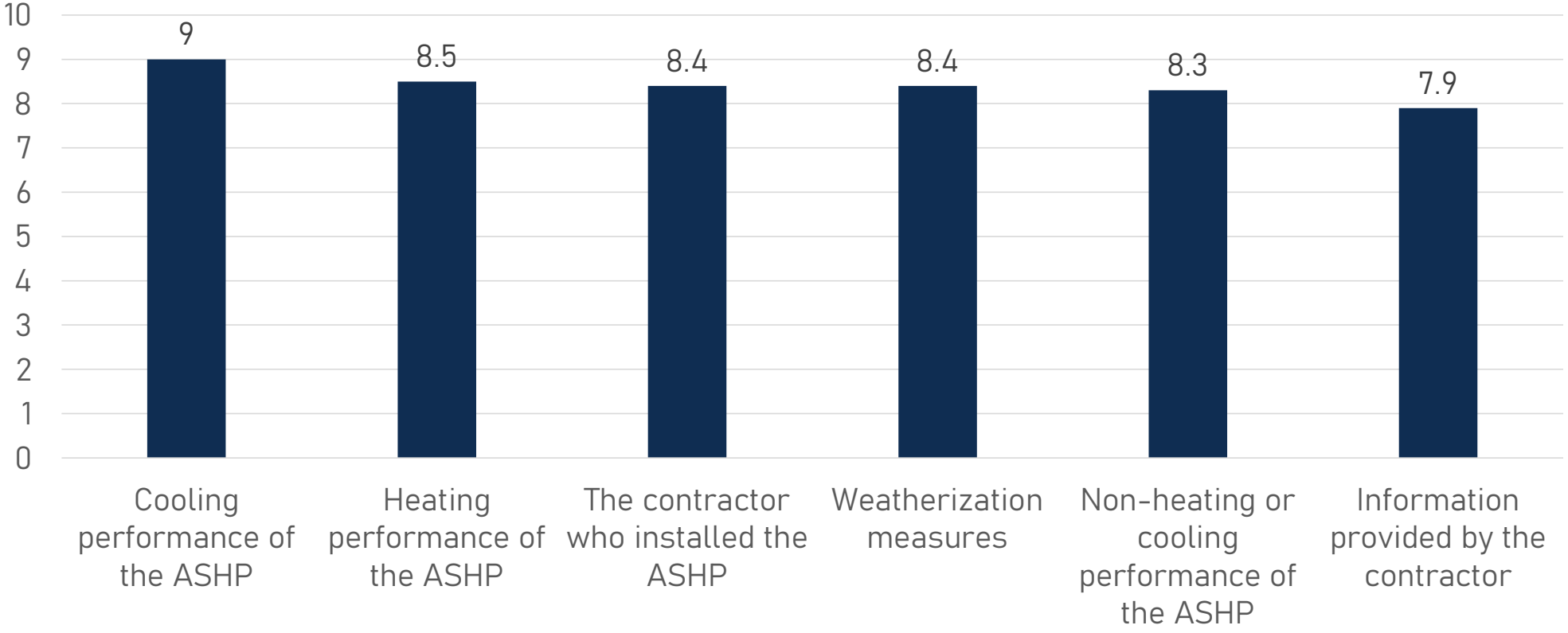
NYSERDA research example

- **Customer survey**
  - 628 customers
  - ASHPs installed in MA and NY
    - Single-zone ductless, multi-zone ductless, and ducted installs
    - Dual fuel and all-electric
    - Mostly cold-climate units

Customer motivation to install ASHPs



Customer satisfaction with ASHPs

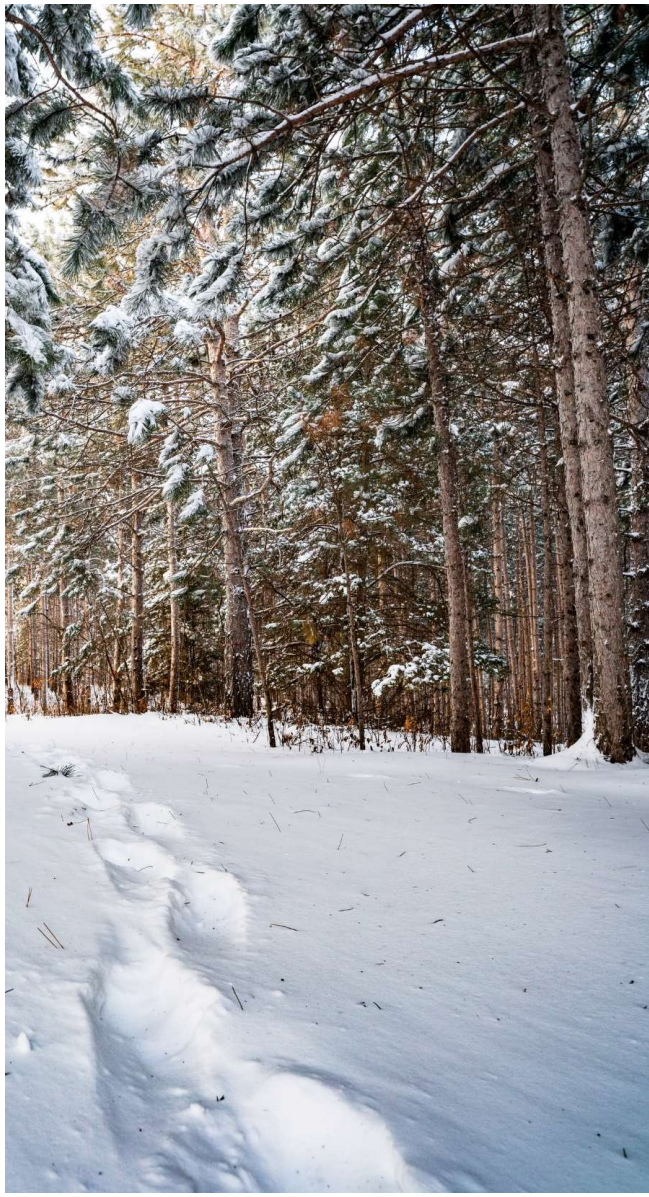


Overall, customers reported an extremely high likelihood to recommend an ASHP to others (8.9/10 – 9.3/10, depending on application type)

https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/Program-Evaluation/Residential-ccASHP-Building-Electrification-StudyAugust-2022.pdf

Really…in cold climates?

- Variable capacity advancements have expanded cold climate performance
- CEE field research studies observed systems delivering heat as cold as –20°F
- CEE field research is validated by other national-level field studies
- Customers report high levels of satisfaction with installed ASHPs



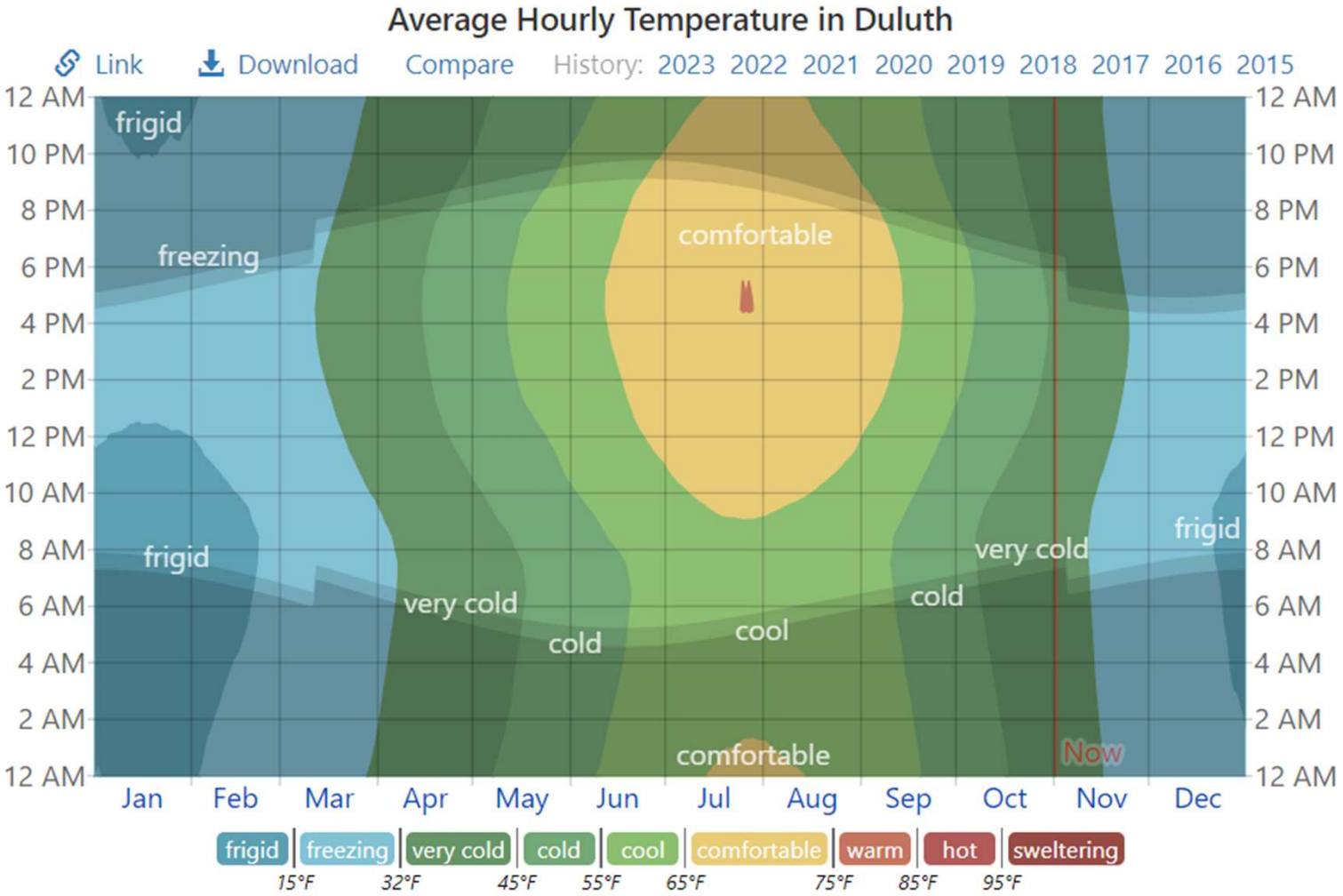
Customer Focus & Business Opportunities

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.



The average hourly temperature, color coded into bands. The shaded overlays indicate night and civil twilight.

[Duluth Climate, Weather By Month, Average Temperature (Minnesota, United States) - Weather Spark]

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)

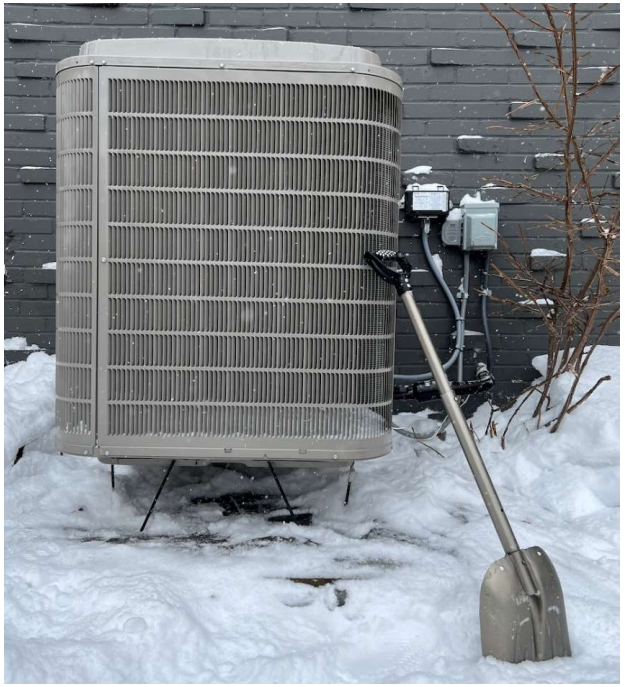


Photo credit: Jeff Curtes, Auer Steel

Happy, well-educated homeowners are the best salespeople

Sizing and Design Considerations

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Does sizing really matter? – From research

If single speed HPs are **oversized by more than 33%, up to a 10%** energy use/**cost penalty** may be seen.

If variable capacity HPs **oversized for heating by more than 40%, up to 10%** energy use/**cost penalty** may be seen.

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 <u>48%!</u>

NIST, NREL, Proctor Engineering, Illinois Institute of Technology

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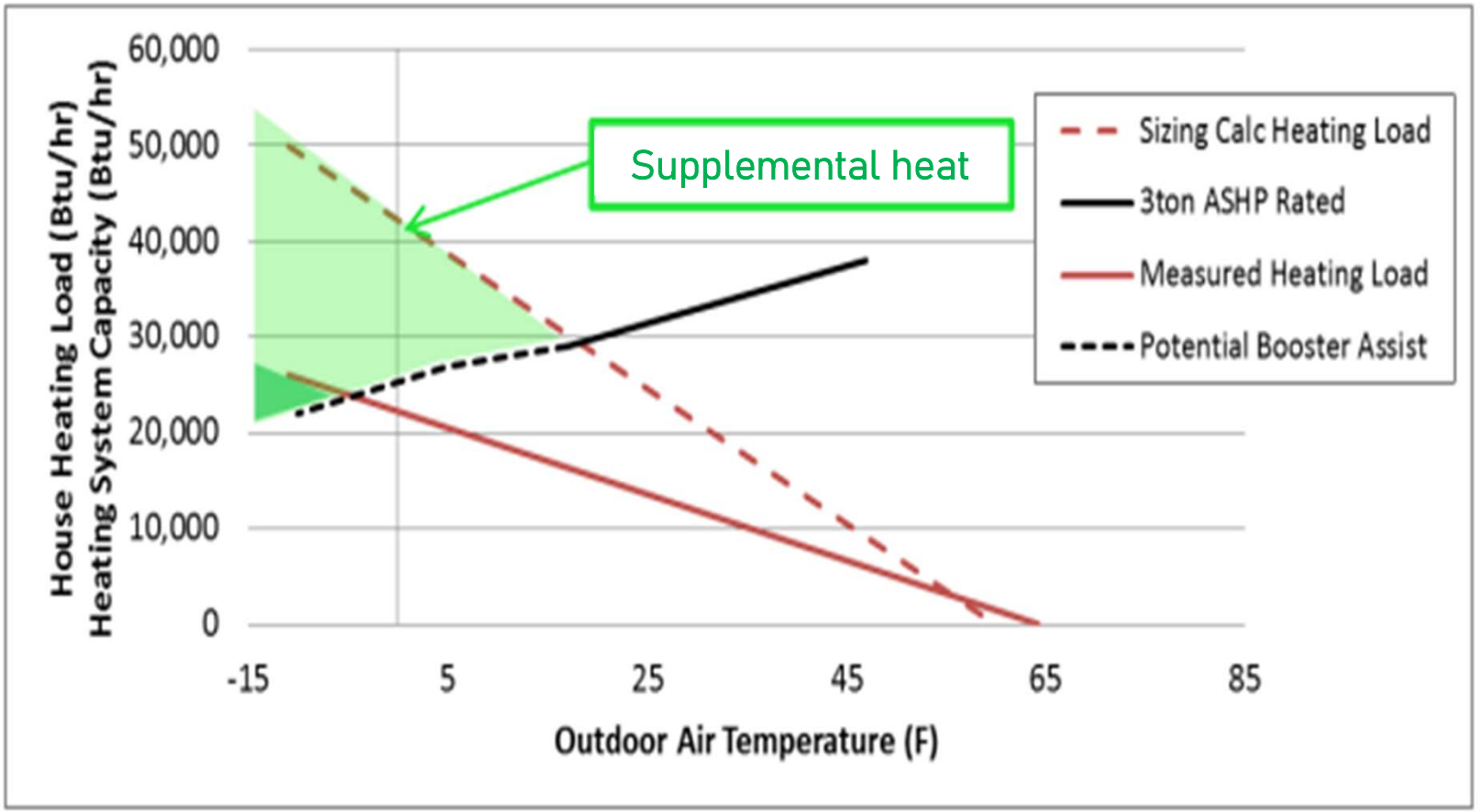
Example of why to not add weights to Manual J

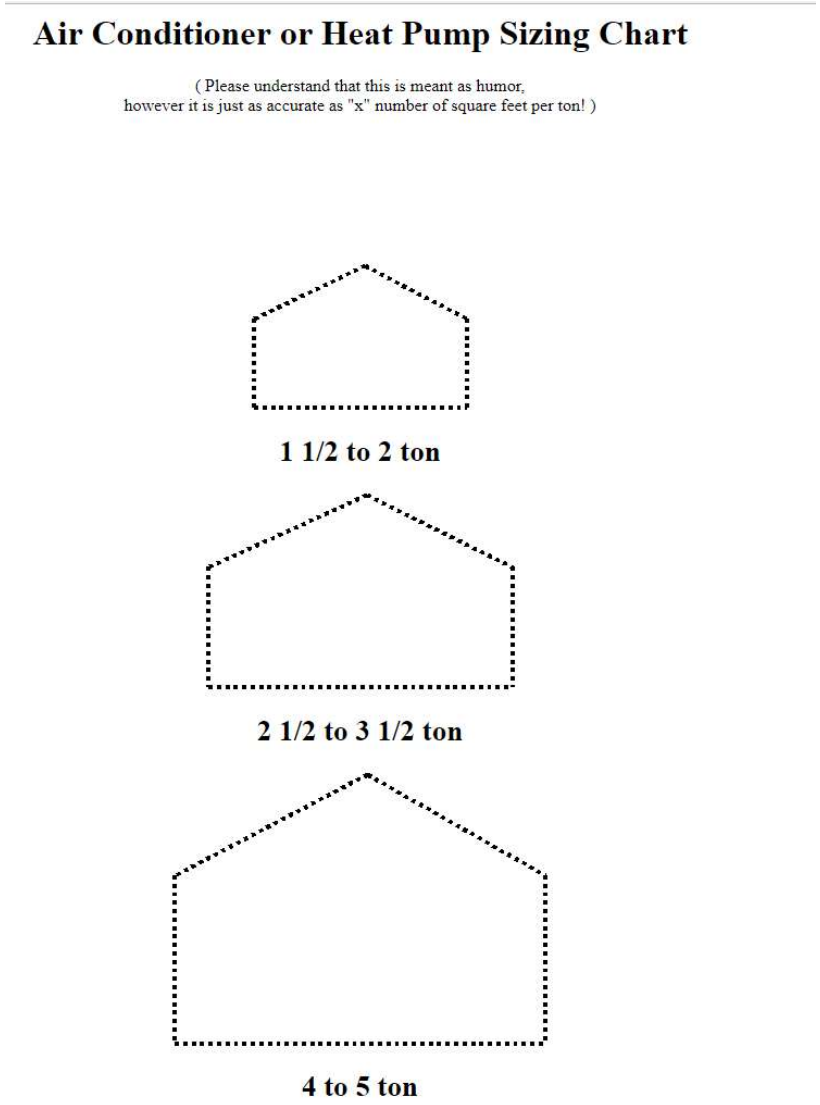
Figure 3. Capacity vs. Outside Air Temperature



Note the supplemental heat needed when you "fudge" factor in Manual J

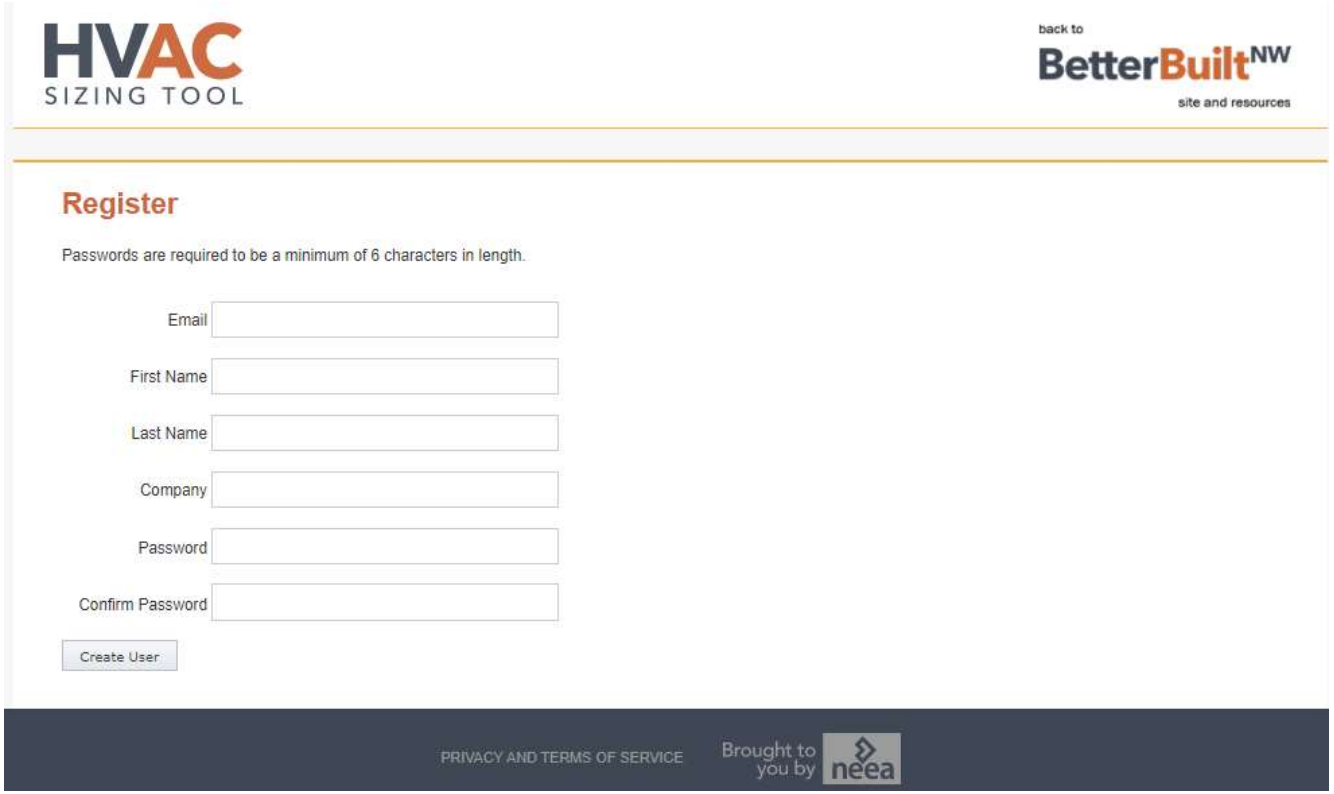
Sizing – Rules of Thumb

- 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!



Slide courtesy Bruce Manclark, CLEAResult

Free Sizing Tool online we are using today



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

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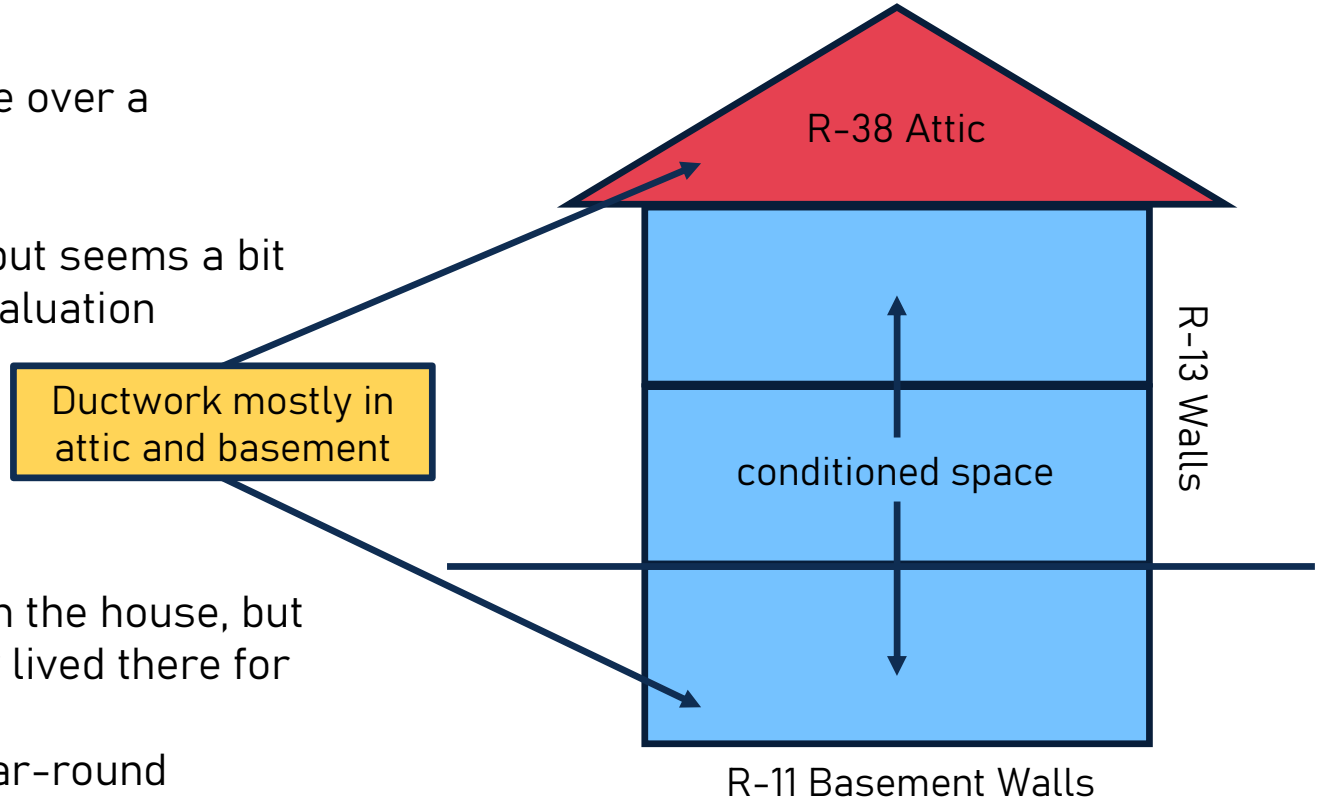
Example House

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



Example House

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

HVAC SIZING TOOL

Building

Conditioned Floor Area	2250	Floors Above Grade	2
Average Wall Height	8.5	Bedrooms	3

Default Insulation Level	2x4 weatherized 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

St Cloud example house 2

Site ID:	**13375**	Heating:	**52,100** BTU/hr
Area:	**2,250** ft^2	Cooling:	**23,700** BTU/hr
Climate:	**St. Cloud AP**	Latent:	**3,000** BTU/hr

Man J = 4.3 tons

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What did we learn about old school rules of thumb?

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).

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

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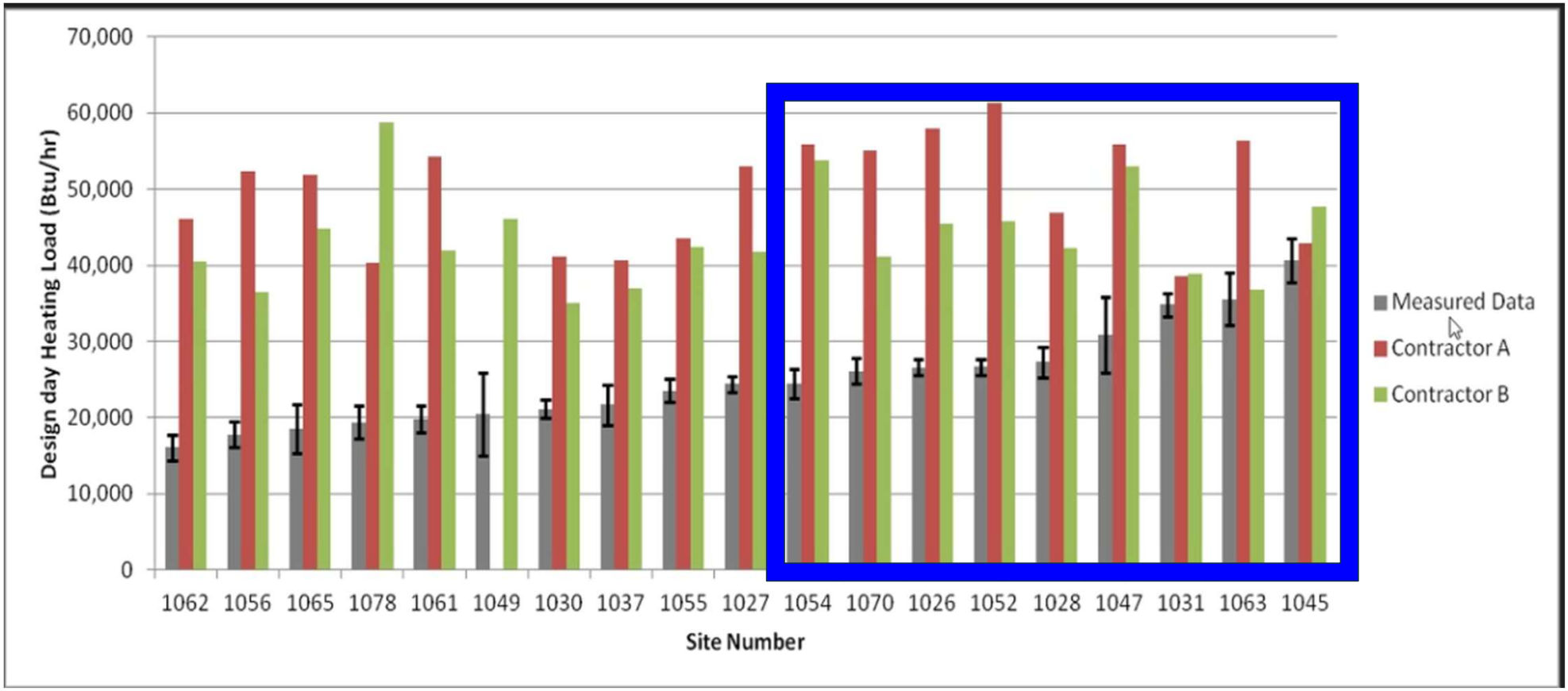
Still concerned that Manual J won't size large enough?



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

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

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Chart courtesy of the Northwest Energy Efficiency Alliance

Ductwork Assessment

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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

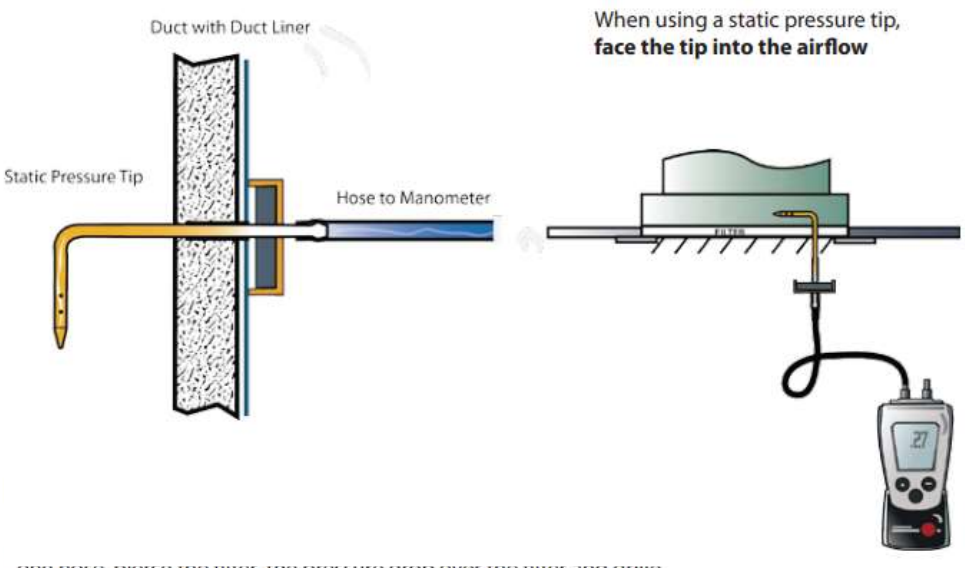
Airflow Before Charge – the mantra of service technicians everywhere!

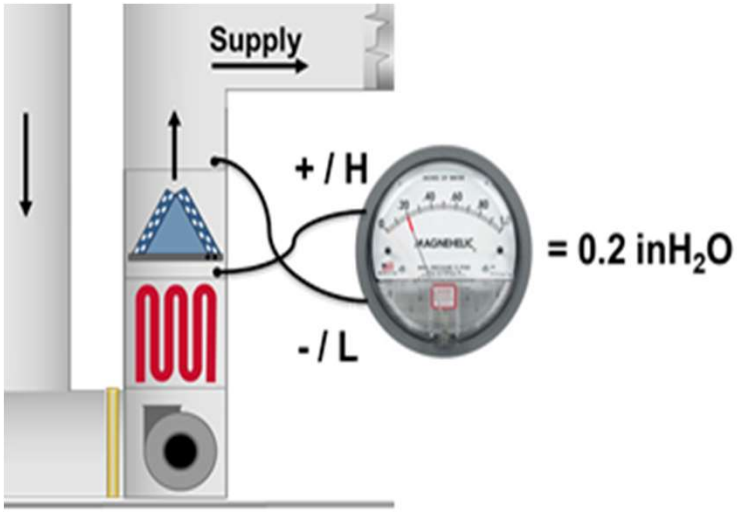
Evaluating existing ductwork

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.**

Static pressure measurement

- Static pressure is the resistance to airflow in ductwork
  - Impacts fan/blower power draw, how hard the system is working, actual delivered btu/hr
- Measurements must be taken using a static pressure probe/tap
- Measure the static pressure drop across the evaporator coil; use the coil OEM chart to find the corresponding CFM





Static pressure measurement guide video from The Energy Conservatory (TEC):
https://www.youtube.com/channel/UCfQMYm8bWmc-rK1pvMWr-7A

Total external static pressures (TESP)

- **OEMs will advise on ideal inches of water**
  - Every manufacturer is a bit different
- **Measurements should be taken before equipment replacement and after installation**
- **Measurements may use Pascals**
  - 249 Pa per inch of water column

TESP in Inches of water column	
Single Speed ASHPs	VCHPs
0.1	0.1
0.2	0.2
0.3	0.3
0.4	0.4
0.5	0.5
0.6	0.6
0.7	0.7
0.8	0.8
0.9	0.9
1.0	1.0
1.1	1.1
1.2	1.2

https://www.energystar.gov/sites/default/files/specs/National Comfort Institute - Measure and Interpret Static Pressures.pdf

Fan watt draw and pressure

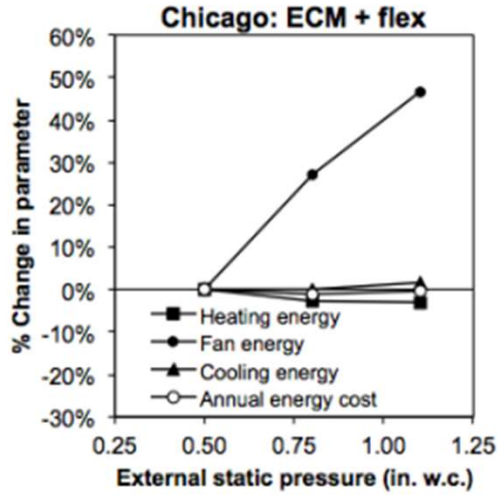


Table 10. Annual energy simulation results for both homes at baseline using the Austin contractor's designs

Home	Duct type	Blower type	Total Pressure (in. w.c.)	Airflow rate (CFM)	Cooling (kWh)	AHU Fans kWh)	Total Electricity (kWh)	Heating ($\times 10^6$ Btu)	Total Gas Consumption ($\times 10^6$ Btu)
Chicago 3-ton AC Gas furnace 1200 CFM nominal	Flex	PSC	0.50"	1200	619	542	8108	60.95	88.88
			0.80"	964	661	531	8139	60.93	88.85
			1.10"	622	786	600	8331	63.71	91.70
		ECM	0.50"	1200	611	319	7878	61.55	89.51
			0.80"	1162	614	411	7972	60.47	88.39
			1.10"	1103	631	478	8056	60.86	88.78
	Metal	PSC	0.50"	1200	611	531	8086	59.52	87.41
			0.80"	964	656	525	8128	60.25	88.16
			1.10"	622	769	583	8300	62.17	90.12
			0.50"	1200	603	314	7861	60.10	88.02

Figure 14. Estimated relative change in annual fan, cooling, and heating energy usage and total annual HVAC energy costs for the Chicago home with both types of AHU fans and both rigid and flex duct work at each duct design (using only the Chicago contractor's duct designs).

We do NOT want to oversize the system for the available ductwork

Envelope Consideration – When to install the heat pump?

Is the homeowner considering or willing to weatherize?

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

How to prioritize timing accordingly:

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

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

Importance of Right Sizing and Selection

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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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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.

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Size for heating or cooling?

Old School

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

New School

1. Start by sizing to largest load for ER, old heat pumps, propane/home heating oil backup*.
2. 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.
3. Likely OK to be within a half ton!

**For Nat Gas, size to cooling load unless the H0 driver is carbon savings.*

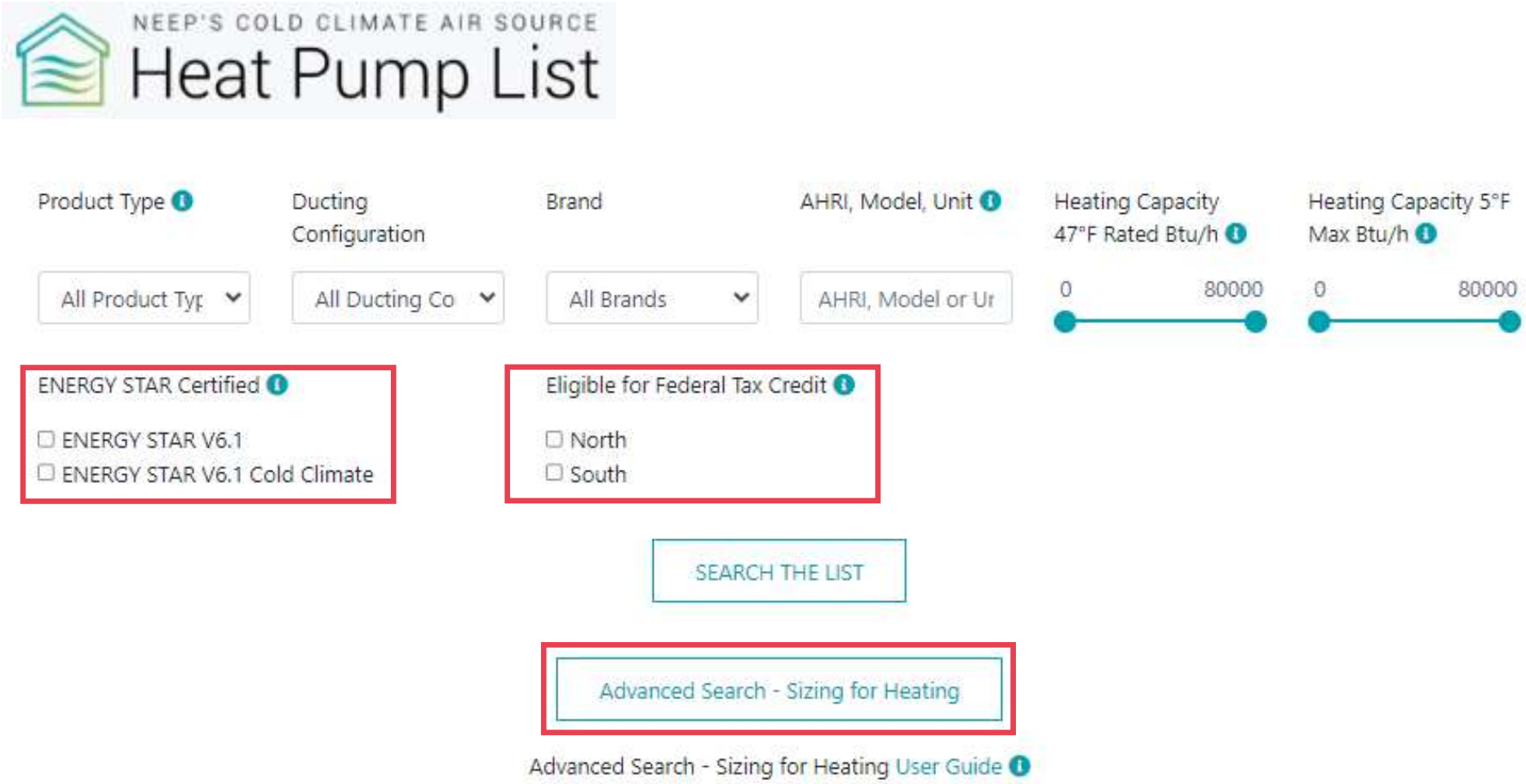
General Design and Selection

- **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:**

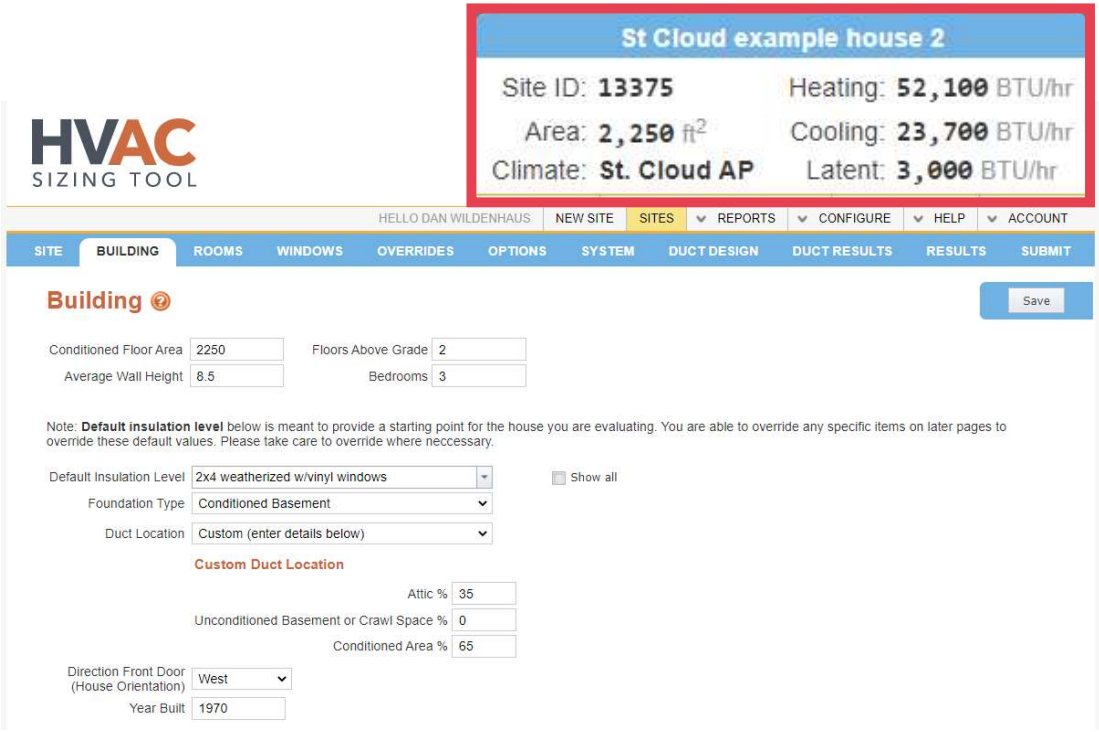
Manual S: Summary
Manual S directs, for central air conditioners and heat pumps, that: • The selected equipment will satisfy the building's total load requirements at design conditions • Manufacturer's product data shows that latent loads are met • Total equipment capacity is between: - 95% and 115% 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.

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



Example House

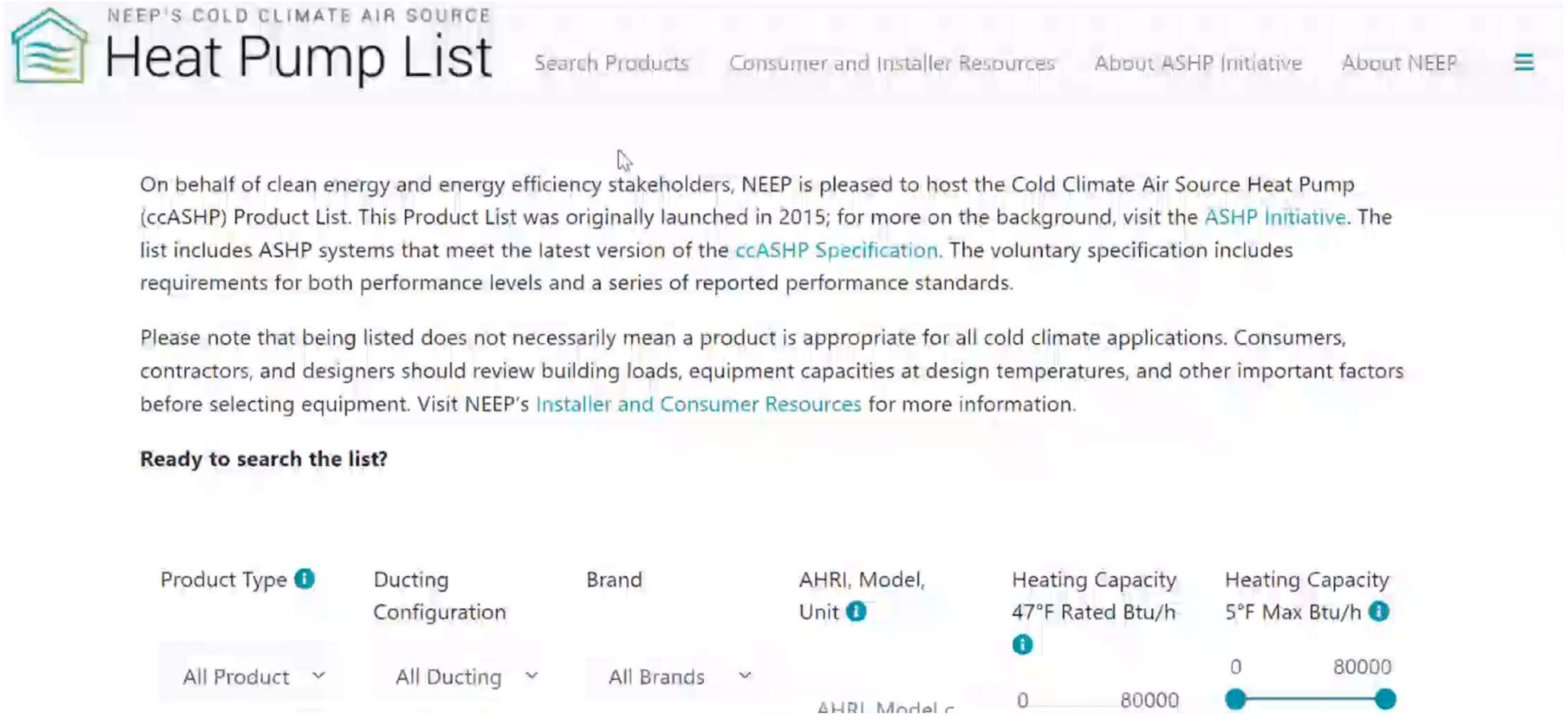
1970 construction
2250 sq ft
3 bedrooms
2 floors above grade
Conditioned basement
R-38 attic
R-13 walls
R-11 basement walls



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

NEEP Tool Walkthrough

St Cloud example house 2	
Site ID: **13375**	Heating: **52,100** BTU/hr
Area: **2,250** ft²	Cooling: **23,700** BTU/hr
Climate: **St. Cloud AP**	Latent: **3,000** BTU/hr



NEEP Tool Walkthrough

St Cloud example house 2

Site ID: **13375**	Heating: **52,100** BTU/hr
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Climate: **St. Cloud AP**	Latent: **3,000** BTU/hr

Back to List

Save PDF

WEATHERMAKER

Central Air Conditioning Heat Pump (HP)

Singlezone Ducted, Centrally Ducted

AHRI Cert #: **208447909**

Outdoor Unit Model #: **38MURAQ48AB3**

Indoor Model #: **40MUAAQ48XA3**

Maximum Heating Capacity (Btu/h) @5°F: **46,000**

Rated Heating Capacity (Btu/h) @47°F: **50,000**

Rated Cooling Capacity (Btu/h) @95°F: **47,000**

Basic View

Advanced Data - Sizing for Heating

Information Tables

Brand	WEATHERMAKER
Series	
Ducting Configuration	Singlezone Ducted, Centrally Ducted
AHRI Certificate #	208447909

Performance Specs

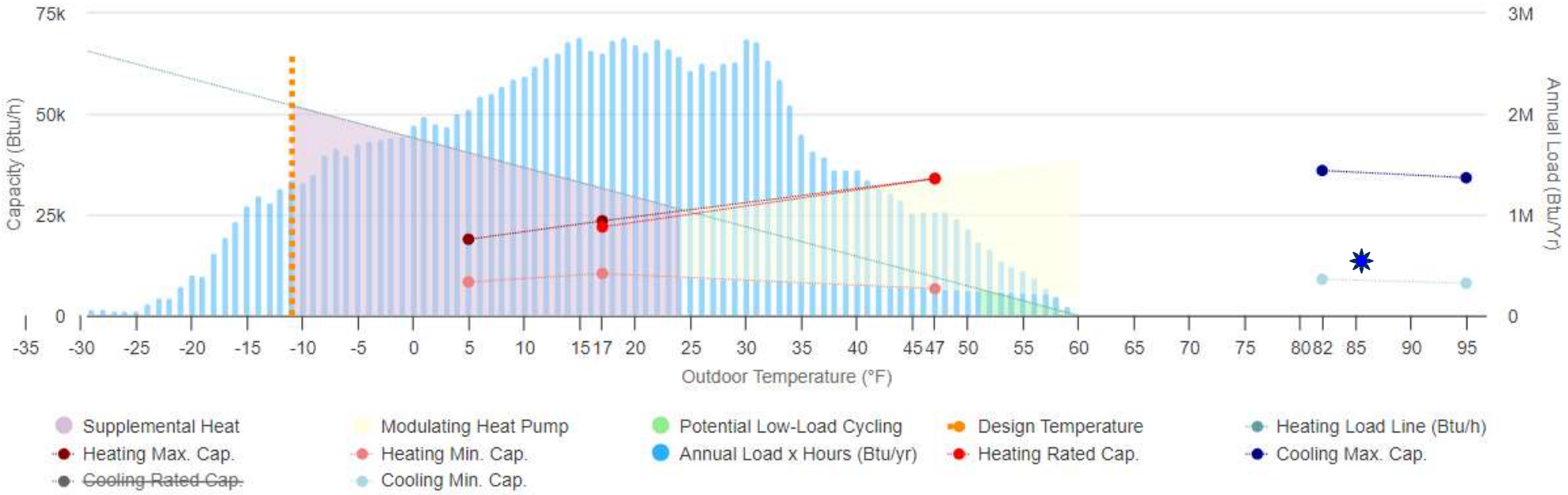
Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated	Max
Cooling	95°F	80°F	Btu/h	17,860	47,000	57,340
			kW	2.18	5.73	6.99
			COP	2.4	2.4	2.4
Cooling	82°F	80°F	Btu/h	19,760	-	31,354

Example House - 4 Ton System

St Cloud example house 2	
Site ID: **13375**	Heating: **52,100** BTU/hr
Area: **2,250** ft²	Cooling: **23,700** BTU/hr
Climate: **St. Cloud AP**	Latent: **3,000** BTU/hr

Maximum Heating Capacity (Btu/h) @5°F: **24,400**
Rated Heating Capacity (Btu/h) @47°F: **48,000**
Rated Cooling Capacity (Btu/h) @95°F: **31,800**

System Capacity, Heating Load, and Weather Data Graph



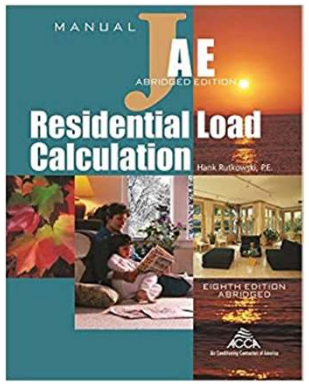
Capacity Balance Point (°F)	24
Minimum Capacity Threshold (°F)	51
Maximum Capacity at Design Temp (Btu/h)	No capacity at design Temperature
Percent Design Load Served	No capacity at design Temperature
Annual Heating Load (MMBtu)	136.4
Percent Annual Heating Load Served	38.0%

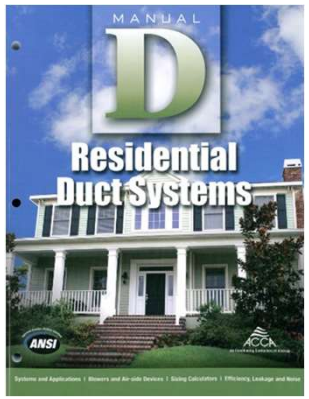
Annual Btu's Covered by Supplemental Heat (MMBtu)	84.6
Hours Requiring Supplemental Heat	2,219
Percent Hours Requiring Supplemental Heat	35.2%
Percent Annual Load Modulating	70.5%
Percent Annual Load with Low-Load Cycling	2.3%

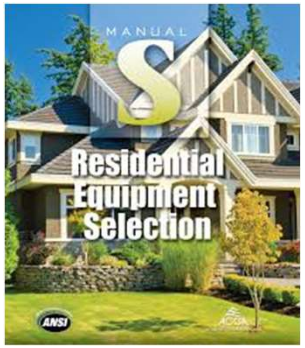
https://ashp.neep.org/

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







Benefits and Considerations by Application Type

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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
Easy Sell – 600,000 homes 30% - 50% energy savings			
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

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

Ducted, dual fuel any heat pump to displace gas furnace and replace AC

Benefits

- Ideal for AC replacement
- Works well with high efficiency gas furnace
- Resilience and future proof
- Homeowner education is an opportunity

Ducted AC and Furnace considerations

- Sizing – heating or cooling load
  - Size up to the heating load for ER, propane, and old heat pumps being upgraded
  - *Reference max capacity at 17°F*

  OR
  - Size to the cooling load for natural gas dual fuel systems

- Compressor Locations
  - City/jurisdiction requirements
  - Local HOA restrictions
  - Placement away from operable windows

- Controls – thermostat setpoints
  - Inquire homeowner motivations
    - Cost savings: use **economic** balance point
    - Carbon savings: use **capacity** balance point

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

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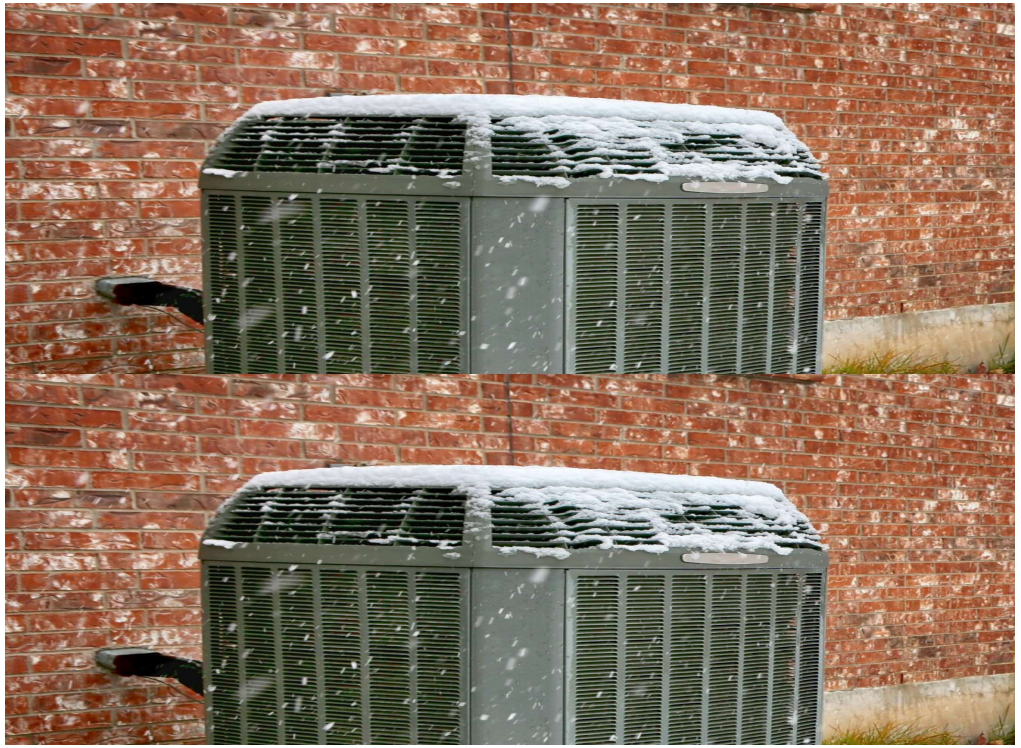
All electric cold-climate heat pump
to replace propane/home heating oil/electric furnace and AC

Benefits

- **Both furnace and AC ready to replace**
  - Ideal for high performance
  - Ideal for propane systems
  - Ideal for poor functioning/older systems
- **Customers interested in reducing their carbon impact**
  - Rooftop solar
  - EV owner



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Ducted ccASHP full replacement considerations

- **Sizing – heating or cooling load**
  - Size for larger load and ensure smaller load will be met!
  - *Consider ductwork and airflow*
  - *Reference max capacity at 5°F*
- **Compressor Locations**
  - City/jurisdiction requirements
  - Local HOA restrictions
  - Placement away from operable windows
- **Controls – thermostat setpoints**
  - Use balance point for switchover temperature or 5°F
- **Electric panel capacity**
  - *Available circuits in panel*
  - *Amperage serving home*

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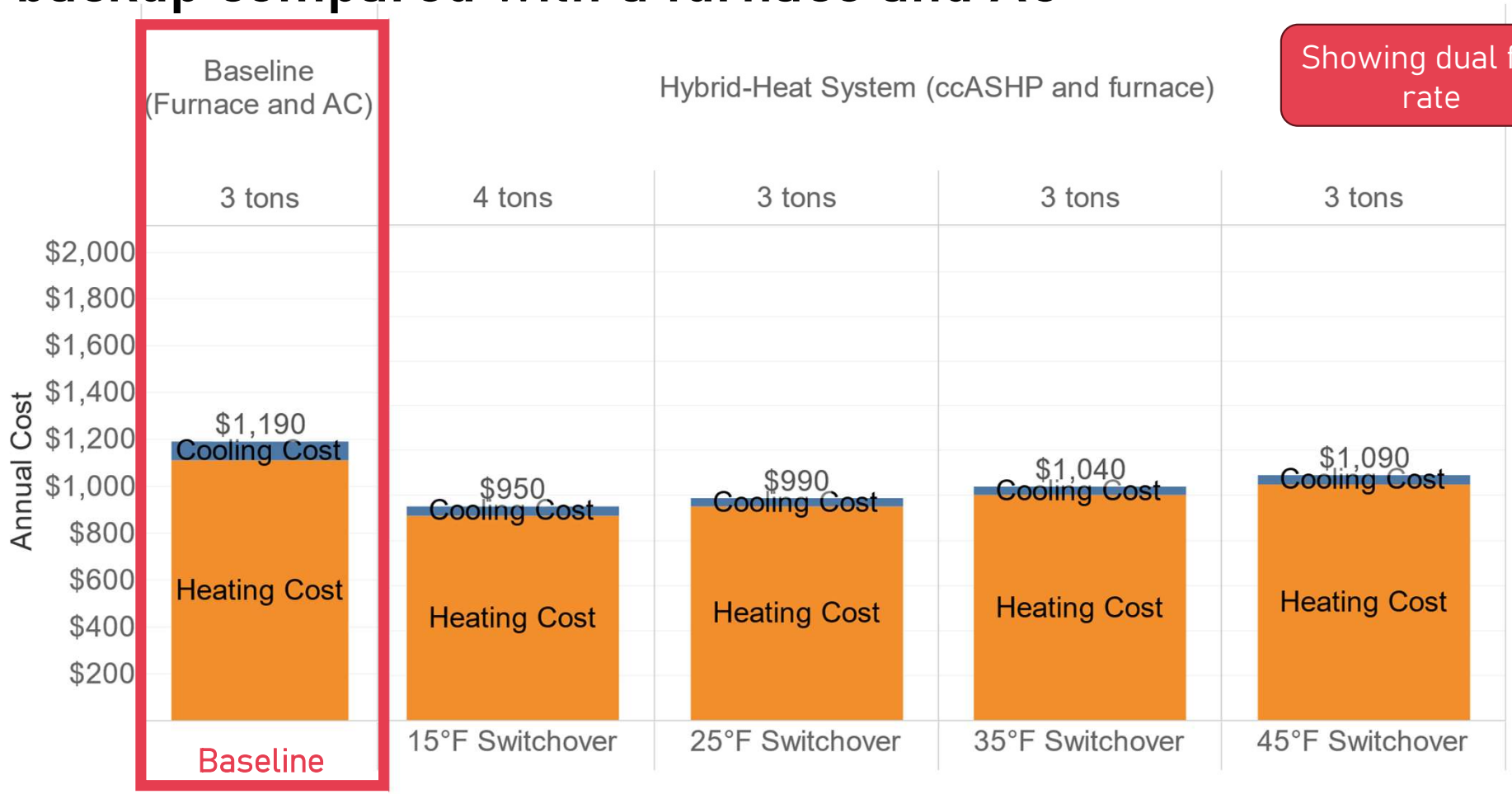
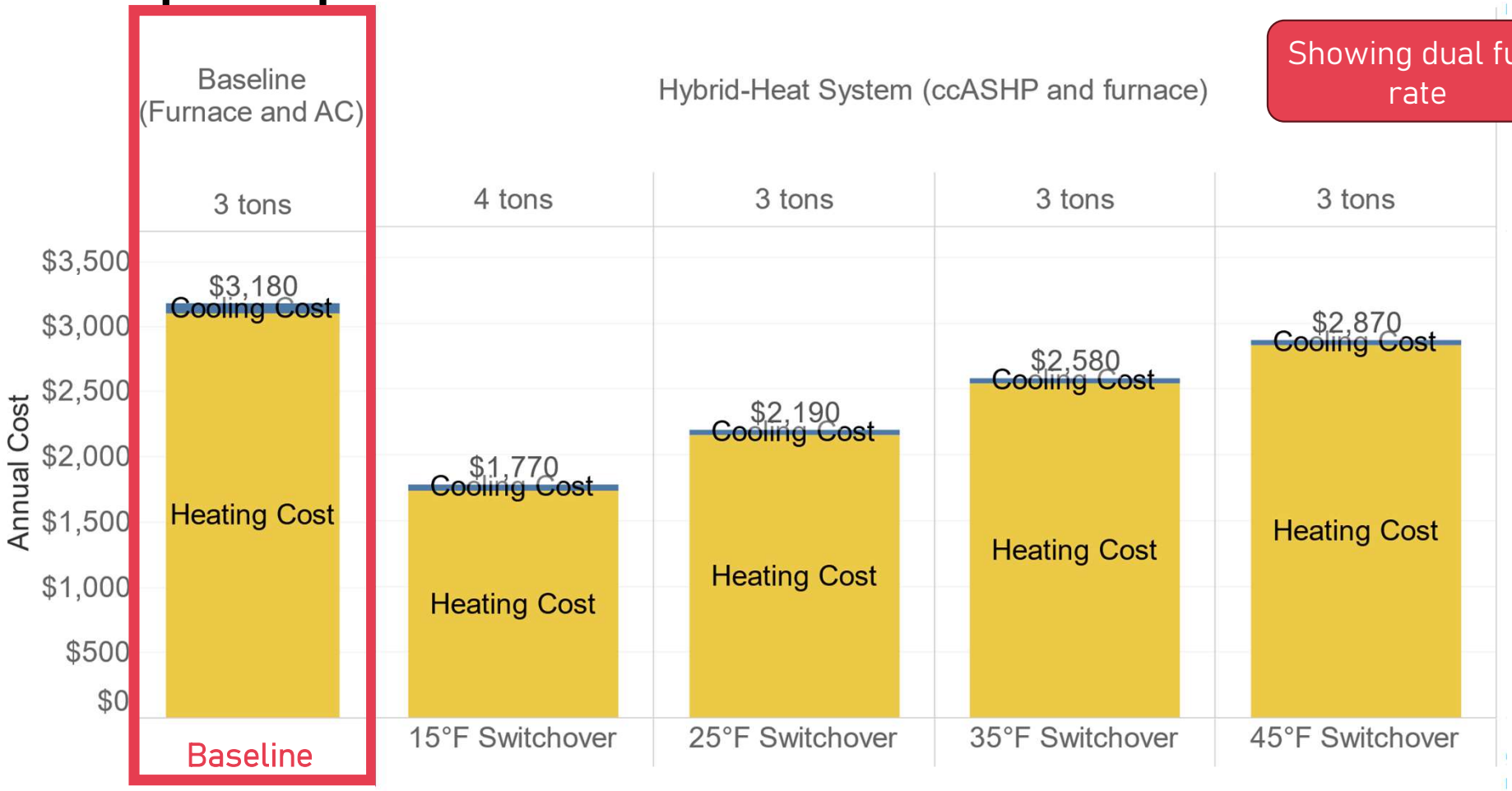
Operating costs: dual-fuel ccASHP with natural gas backup compared with a furnace and AC



Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Dual fuel electric rate: 6¢/kWh; Natural gas: $0.82/therm; Weather station: Duluth, MN

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



Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Dual fuel electric rate: 6¢/kWh; Propane: $2.30/gallon; Weather station: Duluth, MN

Typical Switchover Temps. By Application

Application	Typical switchover temp
ccDHP displacing baseboard heat	0-5° F (compressor lockout no higher than this)
ccASHP displacing propane furnace	Depends on cost of propane and sizing, including duct evaluation 5-25° F
ASHP displacing natural gas furnace	Depends on gas and electric rates & customer motivation: 25-45° F (ccASHP) 35-45° F (two stage HP)

Controls & Installation Considerations

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

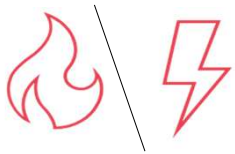
NOT ALL THERMOSTATS ARE DUAL FUEL COMPATIBLE

Selecting a heat pump compatible thermostat is NOT enough

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

The balance point is a TEMPERATURE at which the switchover happens

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.
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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Backup 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

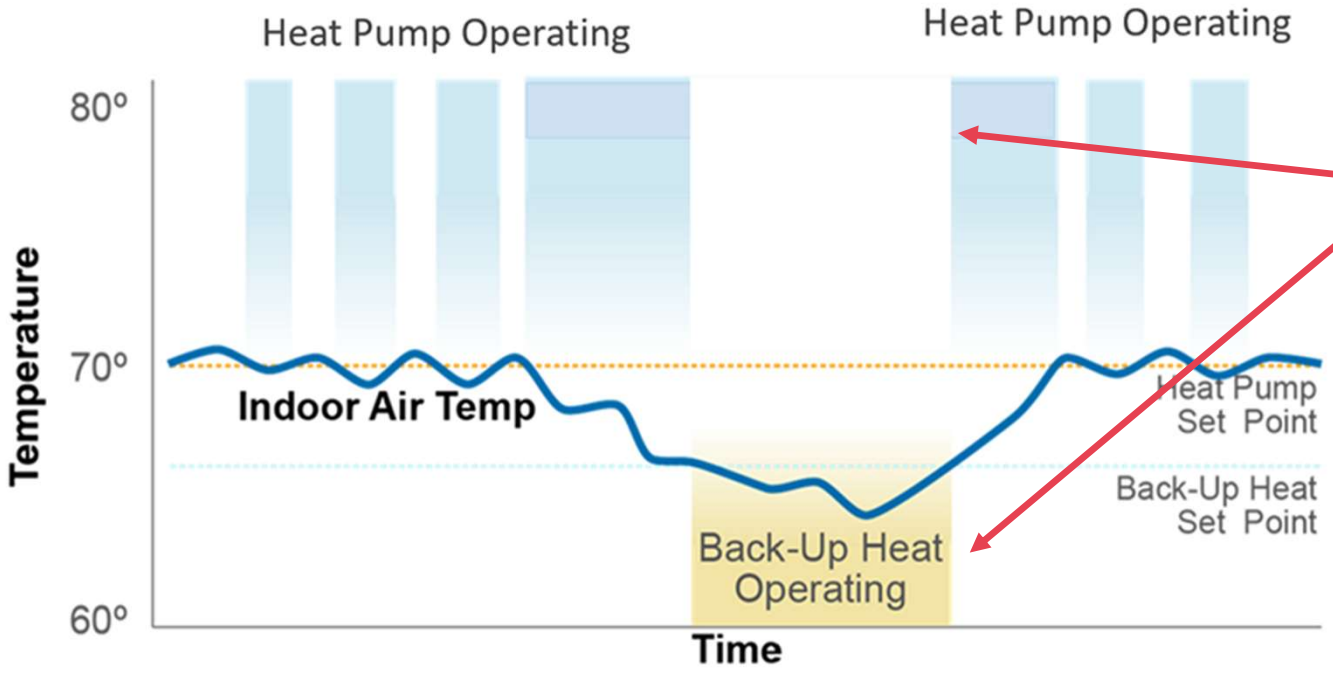
- Droop is a specified temperature value that defines the maximum allowable temperature swing below the heating setpoint before backup heat is engaged.
- Droop can be set to either fully engage or upstage backup heat depending on the system type.
- Once backup heat is activated, it will add heat until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

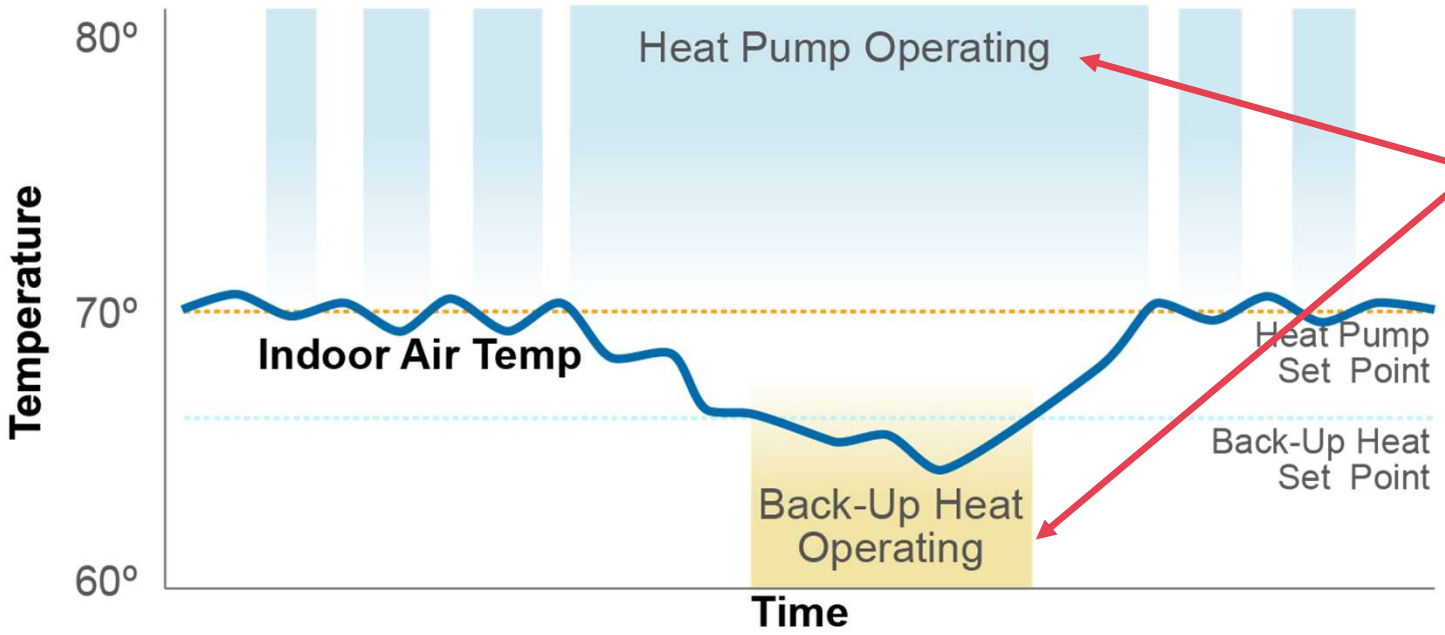
Droop method – Ducted dual-fuel systems



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

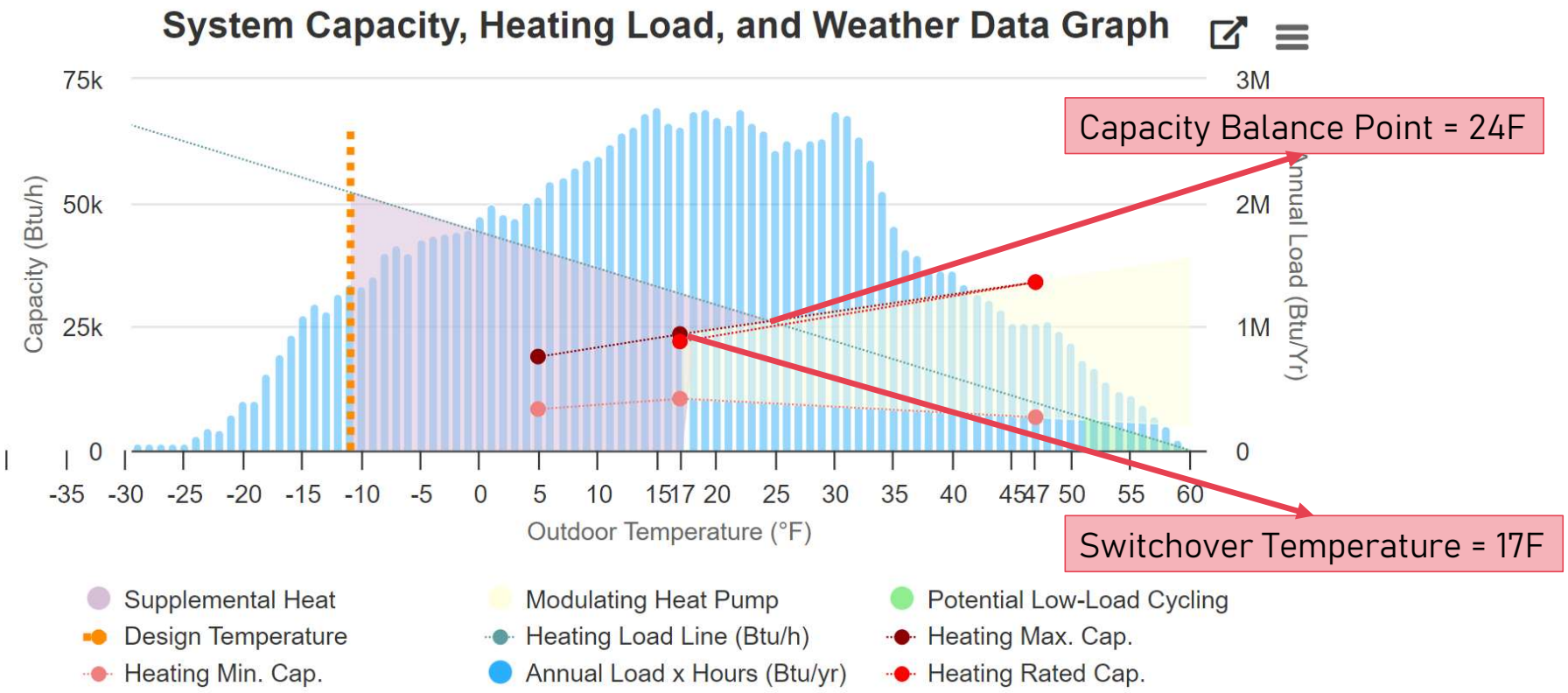
Droop

Droop method – Ducted all-electric or ductless systems



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

Ducted dual-fuel controls example



What happens if the switchover temperature is set below the capacity balance point?

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Ducted dual-fuel controls example

- Droop temperature is **NOT** set in controls

Capacity Balance Point = 24F

7:00 PM	
Indoor Setpoint	72F
Indoor Air	71F
Outdoor Air	26F
Droop	--
Switchover	17F ✗

Heat pump: ON ✓ Furnace: OFF

7:30 PM	
Indoor Setpoint	72F
Indoor Air	68F ↓
Outdoor Air	21F ↓
Droop	--
Switchover	17F ✗

Heat pump: ON Furnace: OFF

8:30 PM	
Indoor Setpoint	72F
Indoor Air	63F ↓
Outdoor Air	19F ↓
Droop	--
Switchover	17F ✗

Heat pump: OFF → Furnace: ON ✓

Potential Outcomes:

- Customer turns on emergency heating mode
- Increased chance of callbacks

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Ducted dual-fuel controls example

- Droop temperature is **set to 3F** in the controls

Capacity Balance Point = 24F

7:00 PM	
Indoor Setpoint	72F
Indoor Air	71F
Outdoor Air	26F
Droop	3F ✗
Switchover	17F ✗
Heat pump: ON ✓	Furnace: OFF

7:30 PM	
Indoor Setpoint	72F
Indoor Air	68F ↓
Outdoor Air	21F ↓
Droop	3F ✓
Switchover	17F ✗
Heat pump: OFF →	Furnace: ON ✓

8:30 PM	
Indoor Setpoint	72F
Indoor Air	70F ↑
Outdoor Air	19F ↓
Droop	3F ↻
Switchover	17F ✗
Heat pump: OFF	Furnace: ON ✓

Outcomes:

- Although the switchover temperature does not engage backup heat, the droop temperature setting turns on the furnace to bring the temperature back up to set point and maintain comfort

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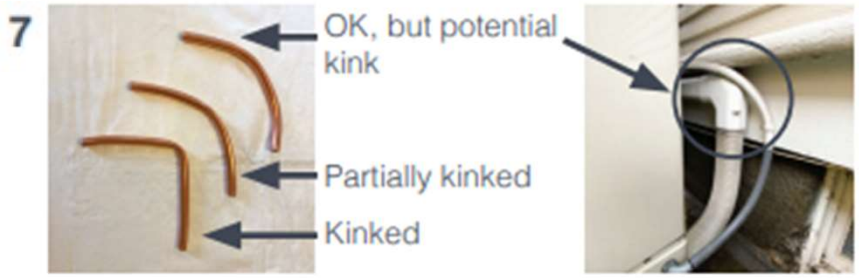
Installation considerations

Compressor placement

Images courtesy of the Northwest Ductless Heat Pump Project

Installation considerations

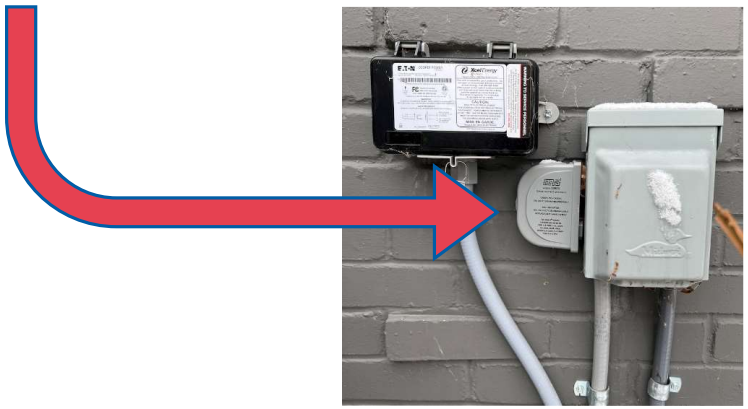
Line set installation



Images courtesy of the Northwest Ductless Heat Pump Project

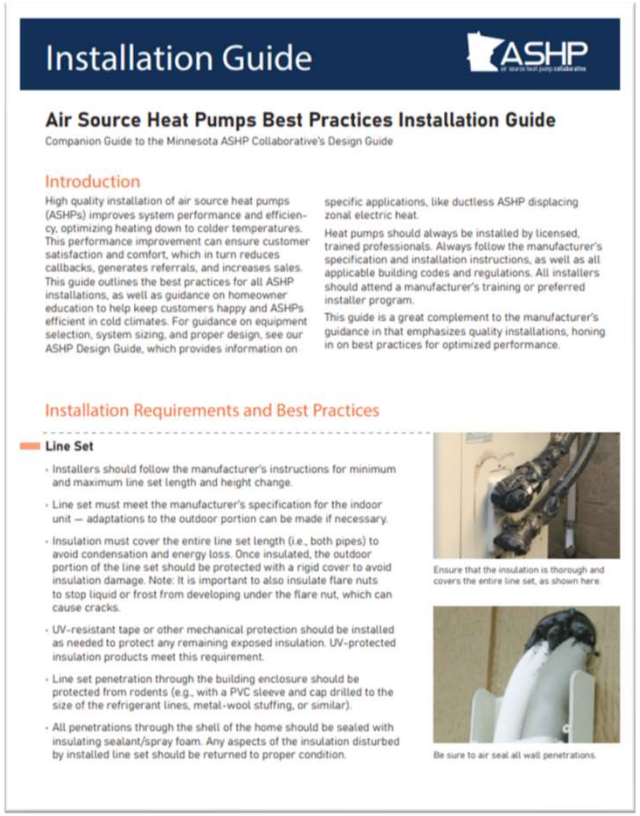
Other considerations

- Condensate management
- Right charged refrigerant
- Proper air sealing and insulation of wall penetrations
- Surge protection – recommended for variable speed equipment



The Best Practices Installation Guide

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


Installation Guide

ASHP

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.

Content Sections

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

https://www.mnashp.org/guides

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Putting this all together

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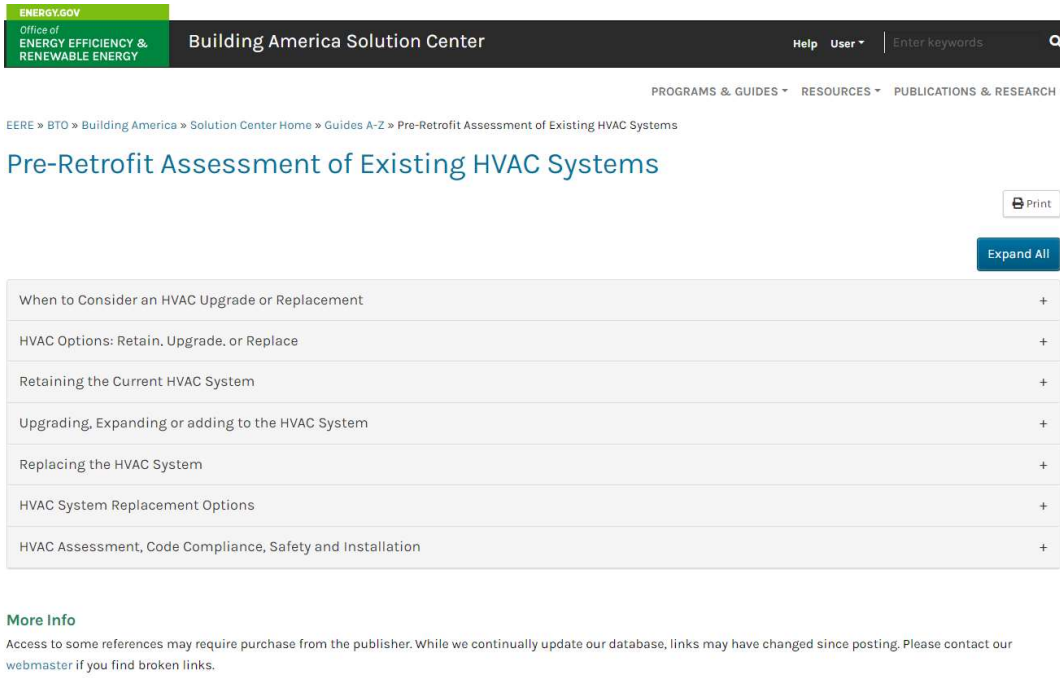
Sales and Comfort Consult

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

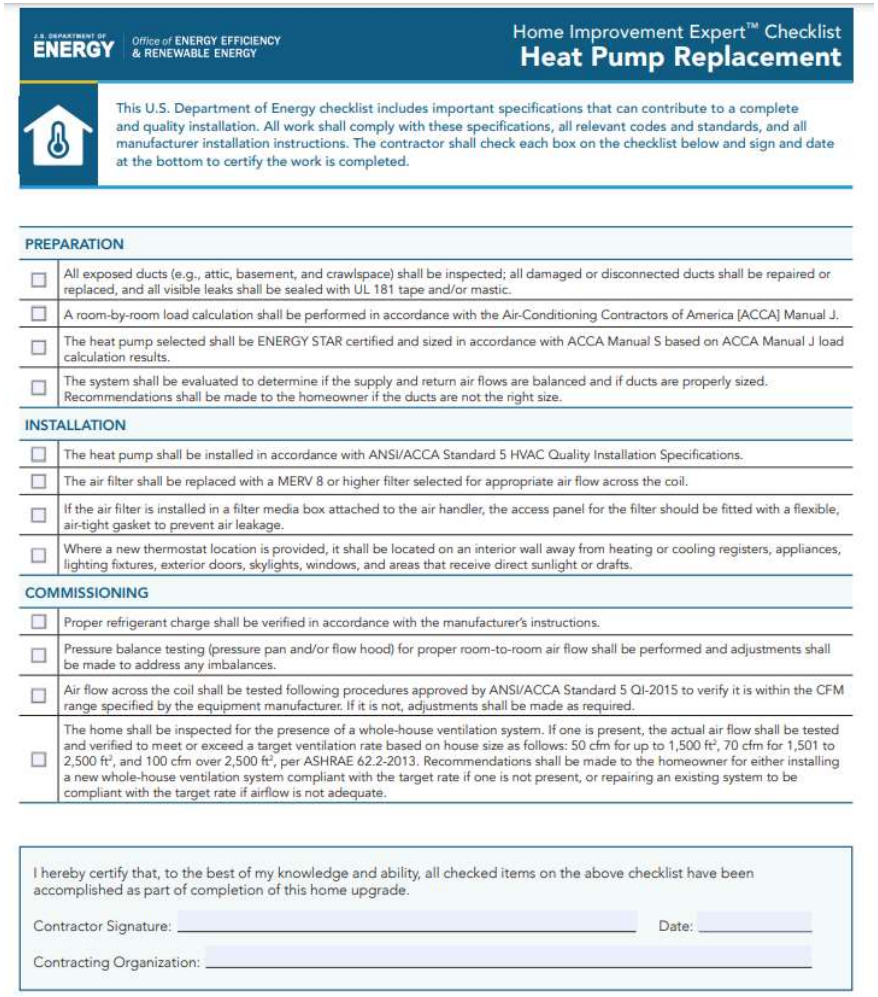


https://basc.pnnl.gov/existing-homes/anytime-equipment-upgrades

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: _____

Maintenance visits

Standing out may be easier than you think…

- Start at the thermostat
- Ask questions about recent utility bills
- Don't be afraid to adjust the balance point (rates for fuel will change)
  - If gas bills went up or electric rates went down – adjust switchover to a lower temperature
  - If gas bills went down or electric rates went up – adjust switchover to a higher temperature

Summary and Key Takeaways

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Summary

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

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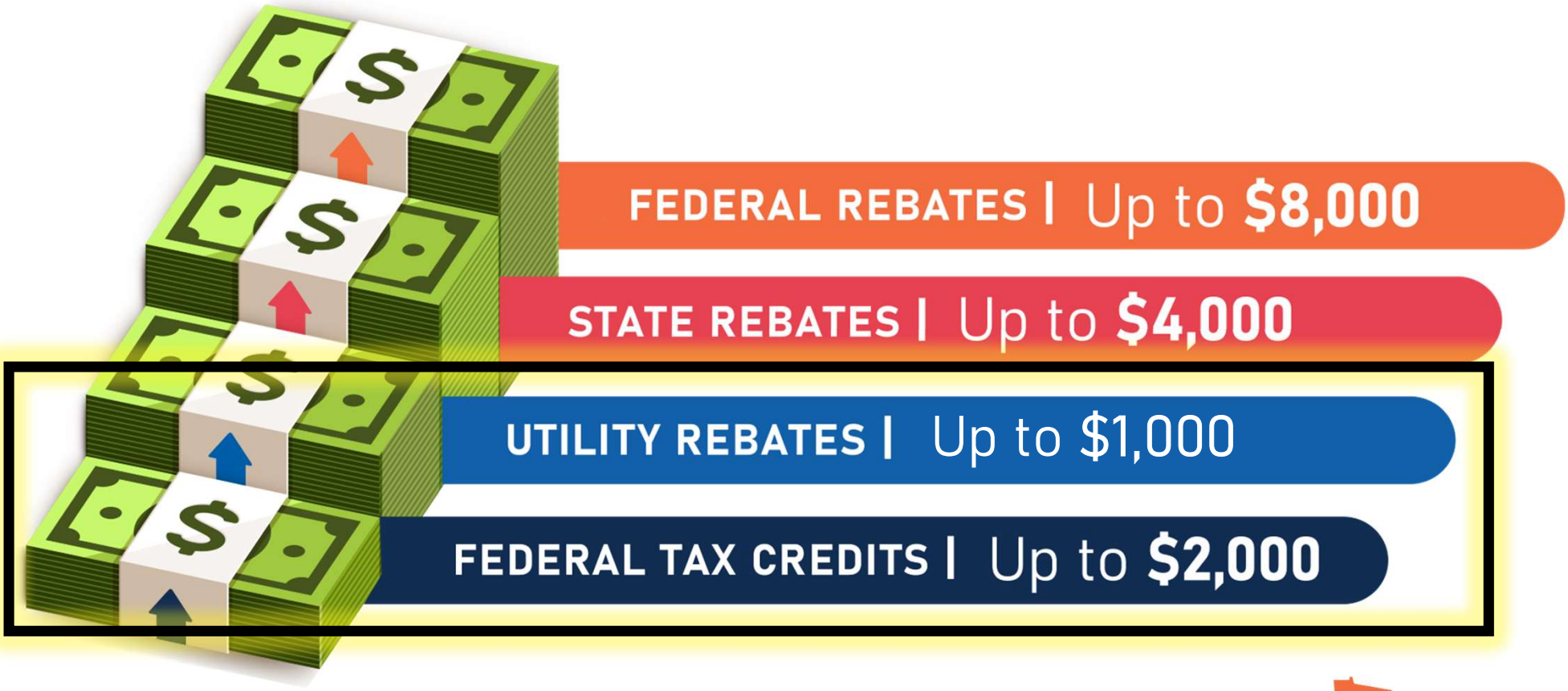
The ASHP Value Stack



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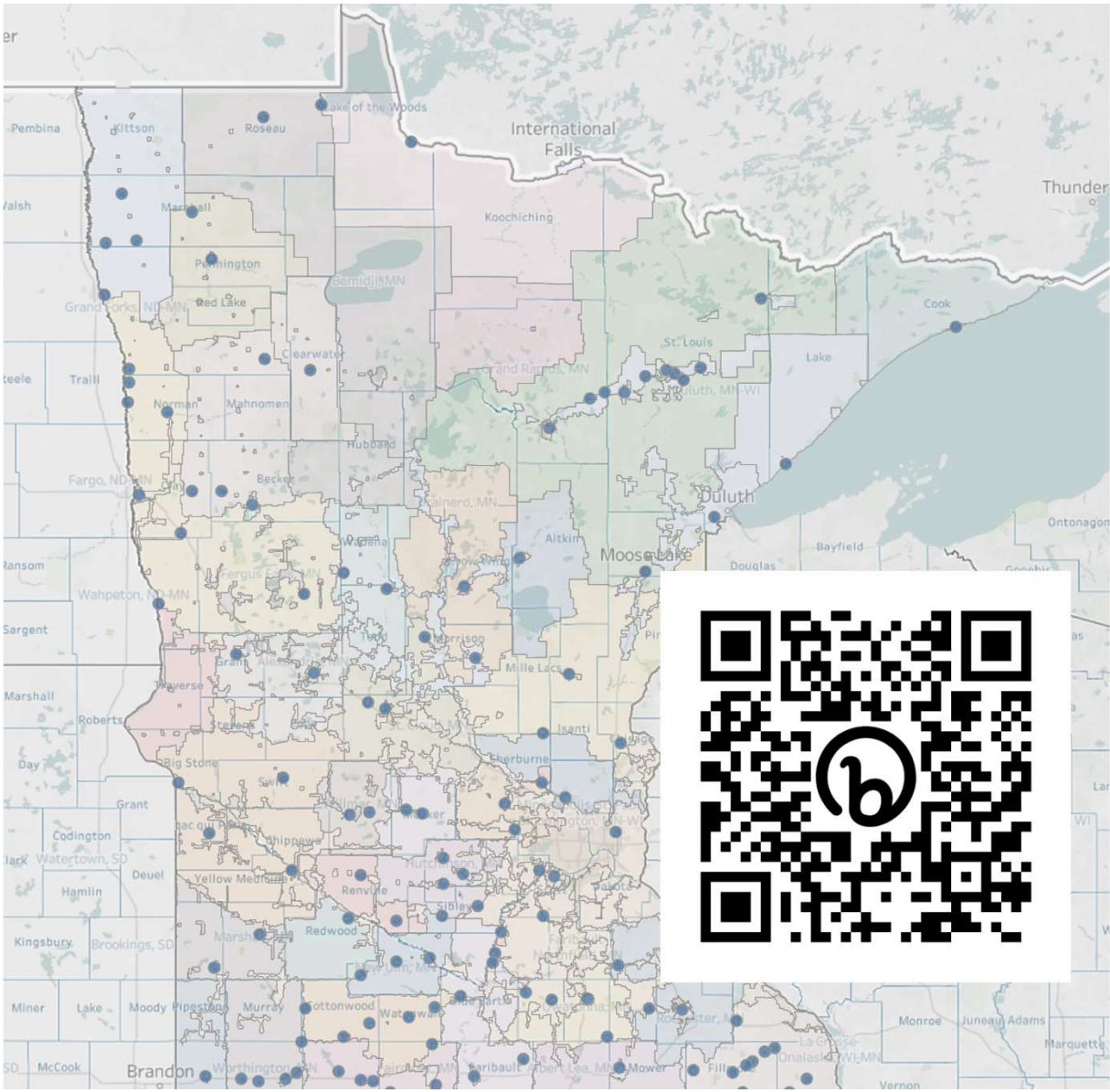
Incentives and Financing Resources

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

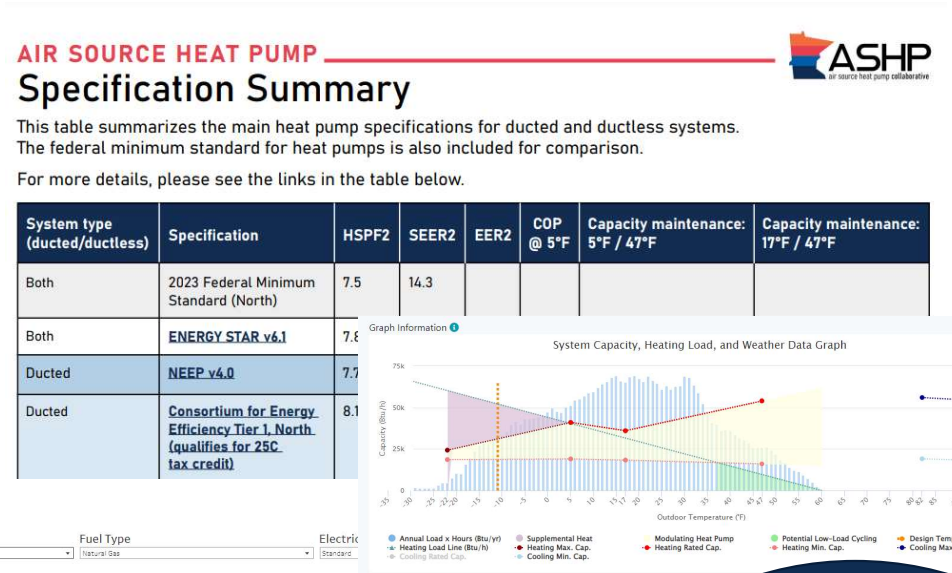
https://www.mnashp.org/incentives-financing



Contractor Resources

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

mnashp.org



AIR SOURCE HEAT PUMP

Specification Summary

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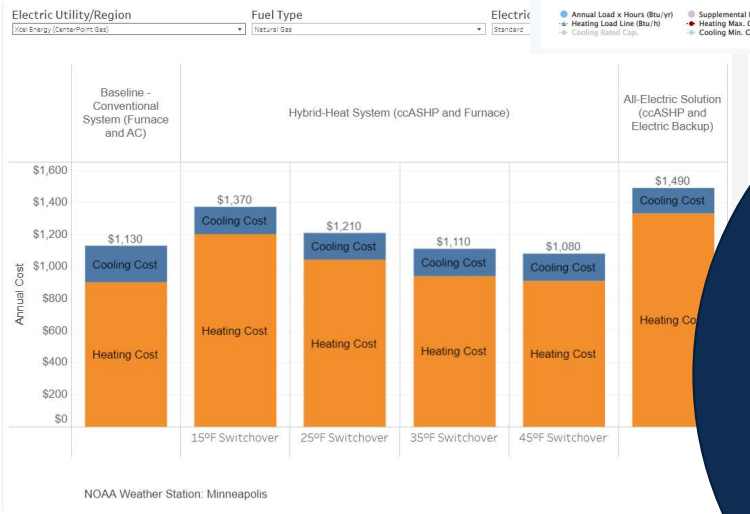
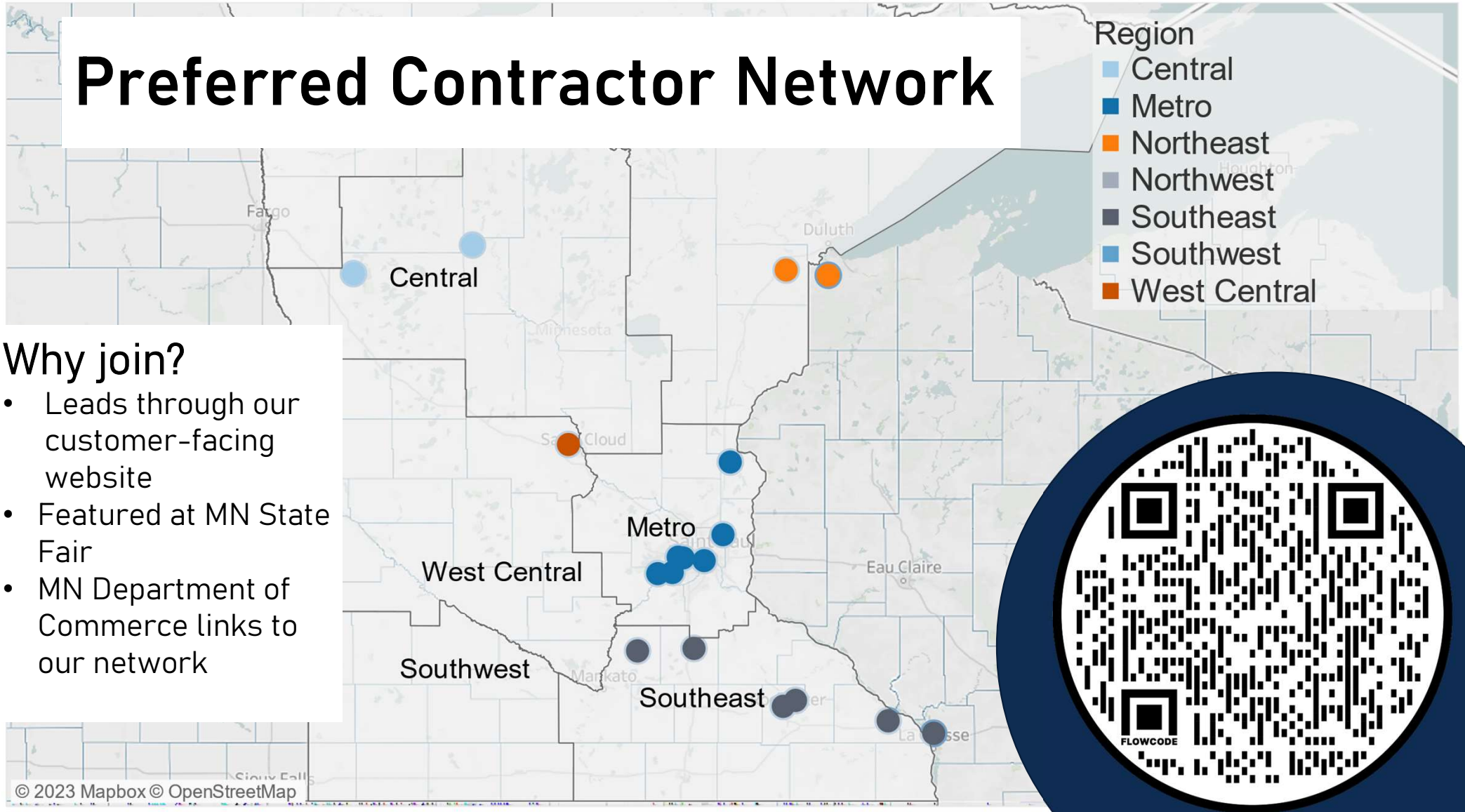
This table summarizes the main heat pump specifications for ducted and ductless systems.
The federal minimum standard for heat pumps is also included for comparison.

For more details, please see the links in the table below.

System type (ducted/ductless)	Specification	HSPF2	SEER2	EER2	COP @ 5°F	Capacity maintenance: 5°F / 47°F	Capacity maintenance: 17°F / 47°F
Both	2023 Federal Minimum Standard (North)	7.5	14.3				
Both	ENERGY STAR v6.1	7.8					
Ducted	NEEP v4.0	7.7					
Ducted	Consortium for Energy Efficiency Tier 1, North (qualifies for 25C tax credit)	8.1					



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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Heat Pump Specifications

Ducted / Ductless	Specification	HSPF2	SEER2	EER2	COP @5F	5°F / 47°F	17°F / 47°F
Both	2023 Federal Minimum HP Standard (North)	7.5	14.3				
Both	ENERGY STAR v6.1	7.8	15.2	11.7			
Ducted	NEEP v4.0	7.7	14.3		1.75		
Ducted	ENERGY STAR Cold Climate v6.1	8.1	15.2		1.75	70%	
Ducted	CEE1 Tier 1 North (Highest) 25C TC	8.1	15.2	10.0	1.75	70%	58%
Ductless	CEE1 Tier 2 North (Highest) 25C TC	9.5	16.0	9.0	1.75	70%	58%
Ductless	NEEP v4.0	8.5	15.0		1.75		
Ductless	ENERGY STAR Cold Climate v6.1	8.5	15.2		1.75	70%	