Center for Energy and Environment

Sizing and Selecting Heat Pumps in Colorado

Part 2 of FREE Heat Pump Training

Your Trainer

Dan Wildenhaus

Sr Technical Manager and Trainer–
Center for Energy and Environment

15 years as a contractor doing HVAC and Weatherization

15 years as a consultant and trainer for utilities and governments

A Colorado resident!

What we'll cover today

- Why Right Sizing Matters Review
- Quick Load Calc Review
- Specifications
- What's in the Design Phase?
- Manual S
- Manual S alternatives
- Options for when Heat Load is 1.5x Cooling Load
- Altitude and Dry Climate Adjustments
- Sizing for Ductwork
- Summary

Please keep yourself muted!

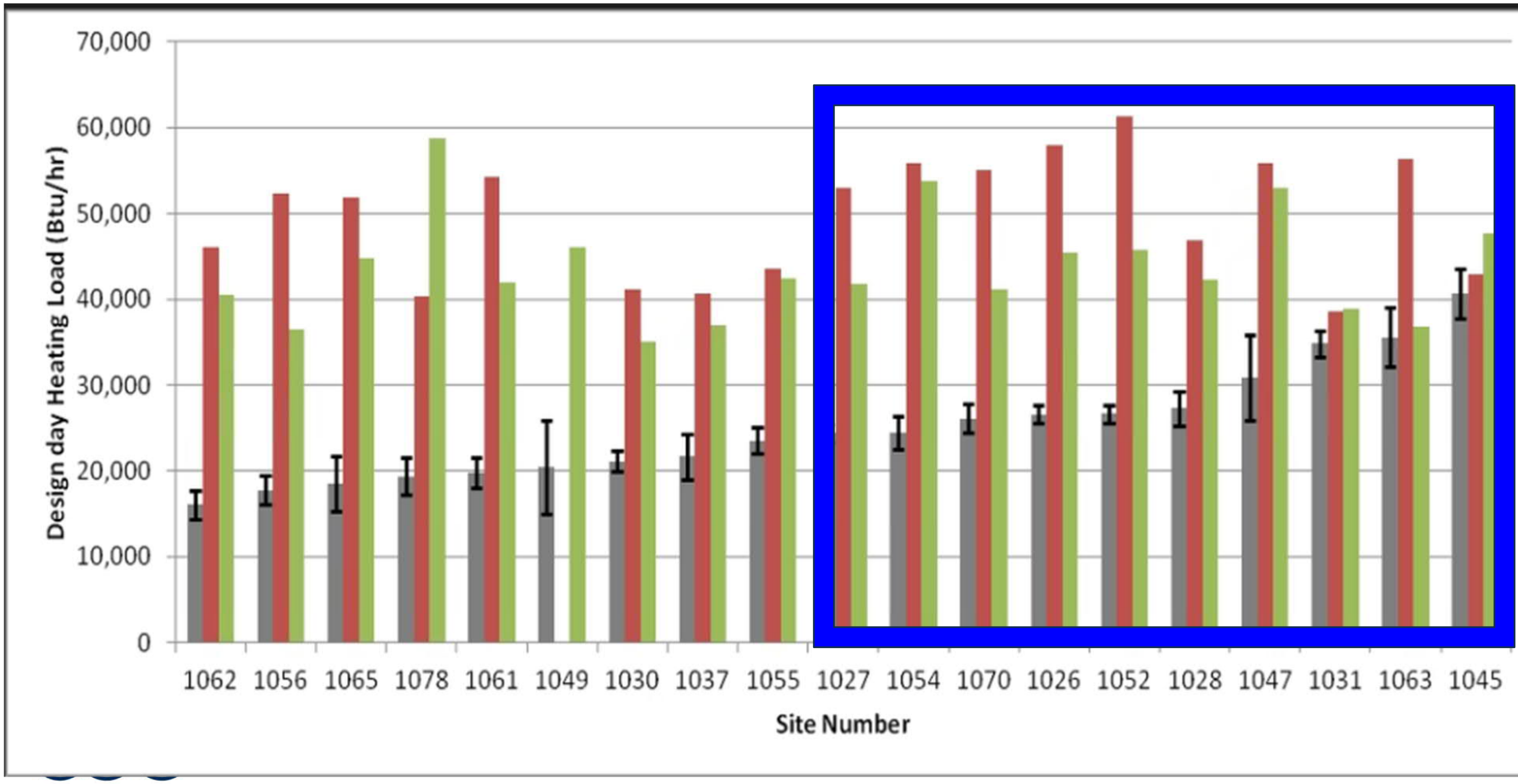
Please type questions and comments into the chat!

Problem statement:

Sizing, design, and selection is often done based solely on rules of thumb or based on previous sized systems.

“Variable Capacity Air Source Heat Pumps perform best and meet savings goals when sized appropriately for system type, application, and supplemental fuel type.”

Concerned that Manual J won't size large enough?



Grey = actual energy use for heating and cooling. The little black "I" for each is the range of accuracy

Does sizing really matter? - From research

If **oversized for cooling by more than 140%, some energy use increase may be seen** (depends on equipment type, brand, algorithms, control strategies and settings, etc..)

If **oversized for heating by more than 150%, some energy use increase may be seen** (depends on equipment type, brand, algorithms, control strategies and settings, etc..)

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

What other real-world challenges may exist when oversizing?

- For filtration, run times matter!
- For ventilation, run times matter!
- For home destratification, run times matter!
- On and off systems can lead to larger temperature swings.
- For humidification, run times matter!
- Larger compressors and fans may require larger electrical circuits.
- Larger compressors and fans may be noisier.
- Oversized systems may struggle with existing ductwork.

Types of Load Calcs Matter!

Quick Review

Block load vs Room-by-room

Block load

- Accurate for whole house systems
- Faster and easier
- Provides necessary sizing data
- Shorter, cleaner reports
- Meets PRPA requirements
- Works with measureQuick and PNNL QI tool

Room-by-Room

- Accurate for whole house and zoned systems
- Required by some code jurisdictions
- Provides necessary sizing data
- Meets PRPA requirements
- Works with measureQuick, PNNL QI tool, and ASHRAE 221

Decision Matrix for type of load calculations

ASHP Application	Room-by-room	BPI Compliant Audit Software	Block load	Existing Equipment Capacities
ASHP installation in a new house, or in a house with significant envelope upgrades	✓		✓	
ASHP retrofit or add-on installation in an existing house with an Energy Audit	✓	✓	✓	
ASHP retrofit or add-on installation in an existing house without an Energy Audit		*Maybe*	✓	*Maybe*

Right option for homes with IAQ and comfort issues

Basically a block load for whole house

Manual J and Equivalent Approaches

ACCA Approved

Equivalent – versions may/may not be ACCA Approved

Free
Man J v7 equivalent
No low-e, only SHGC

Canadian
F280 compliant
Not free

European
Getting ACCA approved
Great for hydronic

Many of these tools have Manual S or similar built in!

Designing for the Heating Load or Cooling Load?

When to size to the cooling load

Size to cooling load when auxiliary heat is less expensive, or they are keeping the furnace

Applicable for:

- Natural gas customers (dual fuel)

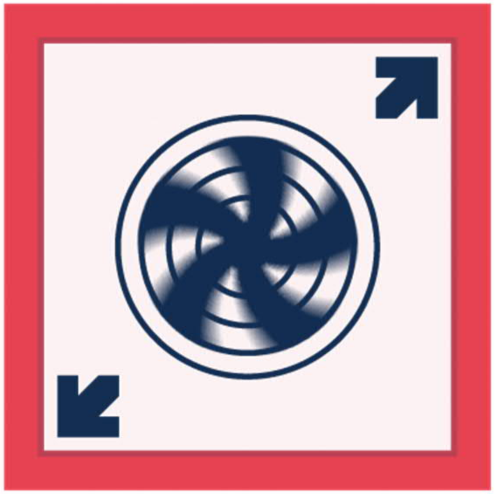
- Note, learn your local programs. Some may only provide incentives if X% of load is met by a heat pump, even in dual fuel scenarios

When to size to the heating load?

Size to heating load to displace an expensive auxiliary heat

Applicable for:

- Propane customers (dual fuel)
- Customers with electric resistance heat
- All-electric system



Important notes when sizing to the heating load

Ensure the system is not oversized for the cooling load*

Variable speed, cold climate systems are recommended for these scenarios

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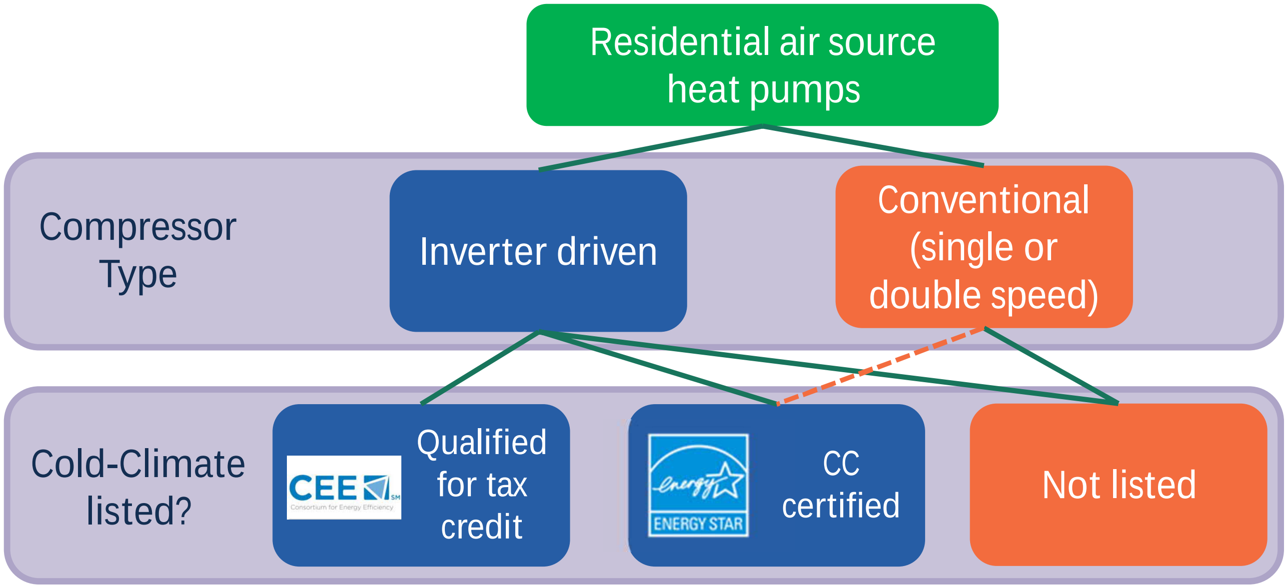
Cold Climate Certifications and Specifications

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!

Specifications in 2025

Measures	Efficiency Works Specs	Xcel Specs	Colorado Tax Credit	Federal Tax Credit CEE1	ENERGY STAR v6.1
Ductless minisplit (cold climate)	21 SEER2, 9.1 HSPF2 ccHP certified Sized for heating or cooling	16 SEER2, 9.5 HSPF2, **11.7 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR 15.2 SEER2, 8.5 HSPF2, 1.75 COP @5 70% cap maintenance Controls Verif Procedure	16 SEER2, 8.5 HSPF2, **9.8 EER2** 1.75 COP @5 **60% cap maintenance**	15.2 SEER2, 8.5 HSPF2, 1.75 COP@5 70% cap maintenance CVP
Standard air source heat pump	15.2 SEER2, 7.8 HSPF2 Switchover below 35ºF	15.2 SEER2, 7.8 HSPF2, **11.7 EER2**	NA	16 SEER2, 8.0 HSPF2, **11.0 EER2** 1.75 COP @5 **45% cap maintenance**	15.2 SEER2, 7.8 HSPF2, 11.7 EER2
Cold climate air source heat pump	15.2 SEER2, 8.1 HSPF2 ccASHP certified Sized for heating	15.2 SEER2, 8.1 HSPF2 **10 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR 15.2 SEER2, 8.1 HSPF2, 1.75 COP @5 70% cap maintenance Controls Verif Procedure	16 SEER2, 8.5 HSPF2, **9.8 EER2** 1.75 COP @5 **60% cap maintenance**	15.2 SEER2, 8.1 HSPF2, 1.75 COP@5 70% cap maintenance CVP

CEE1 25C Heat Pump Tax Credit Specs - 2025

Future Specifications 2026

Measures	Efficiency Works Specs	Xcel Specs	Colorado Tax Credit	Federal Tax Credit CEE1 2025	ENERGY STAR v6.2
Ductless minisplit (cold climate)	21 SEER2, 9.1 HSPF2 ccHP certified Sized for heating or cooling	16 SEER2, 9.5 HSPF2, **11.7 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR 15.2 SEER2, 8.5 HSPF2, 1.75 COP @5 70% cap maintenance Controls Verif Procedure	Same as ducted!	15.2 SEER2, 8.5 HSPF2, COP 1.75 @5 70% cap maintenance CVP
Standard air source heat pump (for dual fuel scenarios)	15.2 SEER2, 7.8 HSPF2 Switchover below 35ºF	15.2 SEER2, 7.8 HSPF2, **11.7 EER2**	NA	**16 SEER2, 8 HSPF2, 11 EER2, 1.75 COP@5, 50% cap maintenance, AHRI 1380**	15.2 SEER2, 7.8 HSPF2, 11 EER2
Cold climate air source heat pump (for whole home electrification)	15.2 SEER2, 8.1 HSPF2 ccASHP certified Sized for heating	15.2 SEER2, 8.1 HSPF2 **10 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR 15.2 SEER2, 8.1 HSPF2, 1.75 COP @5 70% cap maintenance Controls Verif Procedure	**16 SEER2, 8.5 HSPF2, 9.8 EER2, 1.75 COP@5, 65% cap maintenance, AHRI 1380**	15.2 SEER2, 8.1 HSPF2, COP 1.75 @5 70% cap maintenance CVP

ENERGY STAR v6.2 Specification

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PPT Rest

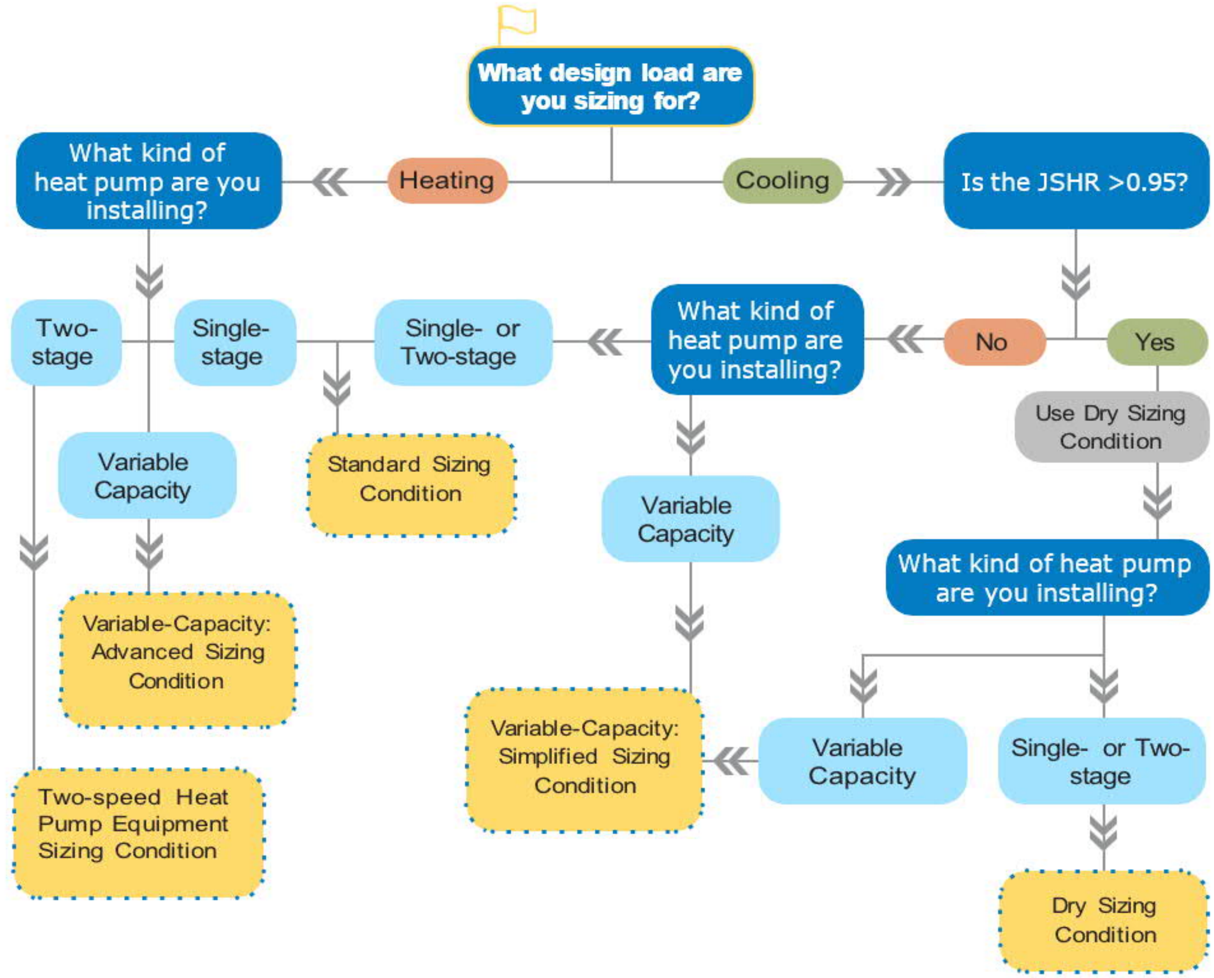
Any questions so far?

Heat Pump Sizing

Specific to Colorados climate

Consortium for Energy Efficiency

Sizing Considerations and System Design Guide



ASHP_Decision_Matrix_and_System_Design_Guide

ASHP_Sizing_Considerations_for_Heating_and_Cooling

What is Manual S really for?

General Design and Selection

Selection, in the form of Manual S (*<u>or alternative</u>*) **involves applying the results of heat and cool load sizing calcs to the selection of equipment** that will **deliver the necessary heating and cooling**, when and where it's wanted. Design and Selection needs to include existing conditions and the application type under consideration. The following is a 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 b[illegible] 95% and 115% of t[illegible] cooling requirements (for air conditioners and heat pumps) or [illegible] 125% [illegible]ling 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.

Updated Manual S sizing guidance

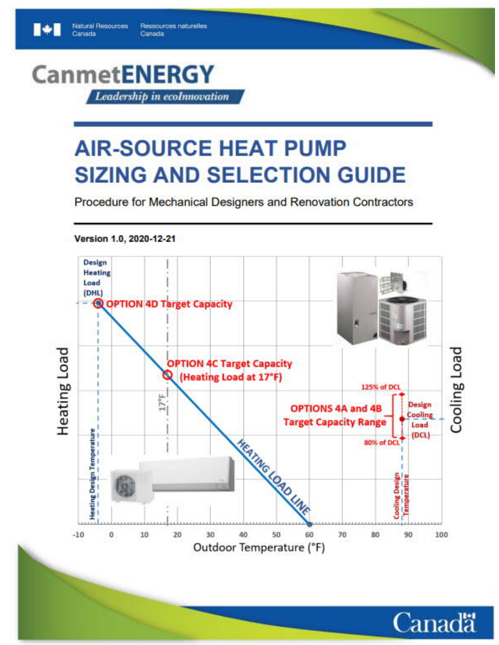
Equipment Type	Heating Size Limit	Cooling Size Limit
Single speed AC	NA	120%
Two Speed AC	NA	125%
SS and TS HPs	120%	120%
Fuel fired furnace/boiler	140%	NA
VCHP = Adv HP Dry Climate	150%	130%
Emergency/Back up ER	175%	NA

The limit is in reference to design loads

NRCAN ASHP Sizing and Selection Guide

Table 3: Mapping Primary Client Objectives / ASHP Applications to the Sizing Options

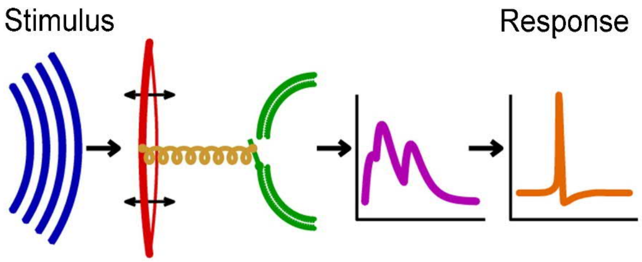
Main Client Objectives / Goals for the ASHP Installation	Option 4A: Emphasis on Cooling	Option 4B: Balanced Heating and Cooling	Option 4C: Emphasis on Heating	Option 4D: Sized on Design Heating Load
Client is primarily interested in cooling. The ASHP is seen as an alternative for a new or existing A/C unit; The backup / existing heating system is seen as the primary heating source for most of the heating season.	✓			
Client is interested in both cooling and ASHP heating. The backup/existing heating system is used primarily during colder weather.		✓		
Client sees the ASHP primarily as a heating source. The backup / existing heating system is used during the coldest periods. Cooling performance is of secondary interest to the client. A CC-ASHP is suggested.			✓	
Client is interested in an ASHP that is sized to provide all or nearly all of the heating at design conditions with little or no use of backup heating. Cooling performance of secondary interest to the client. A CC-ASHP is suggested.				✓



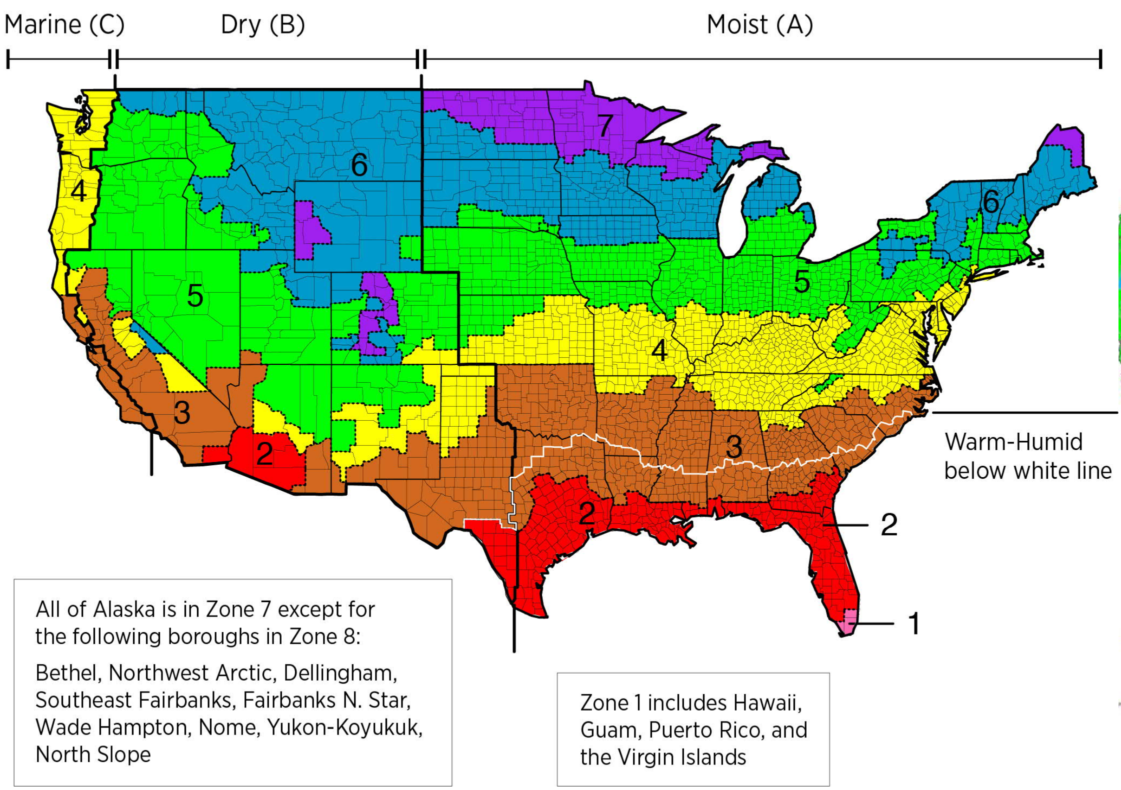
New Goal

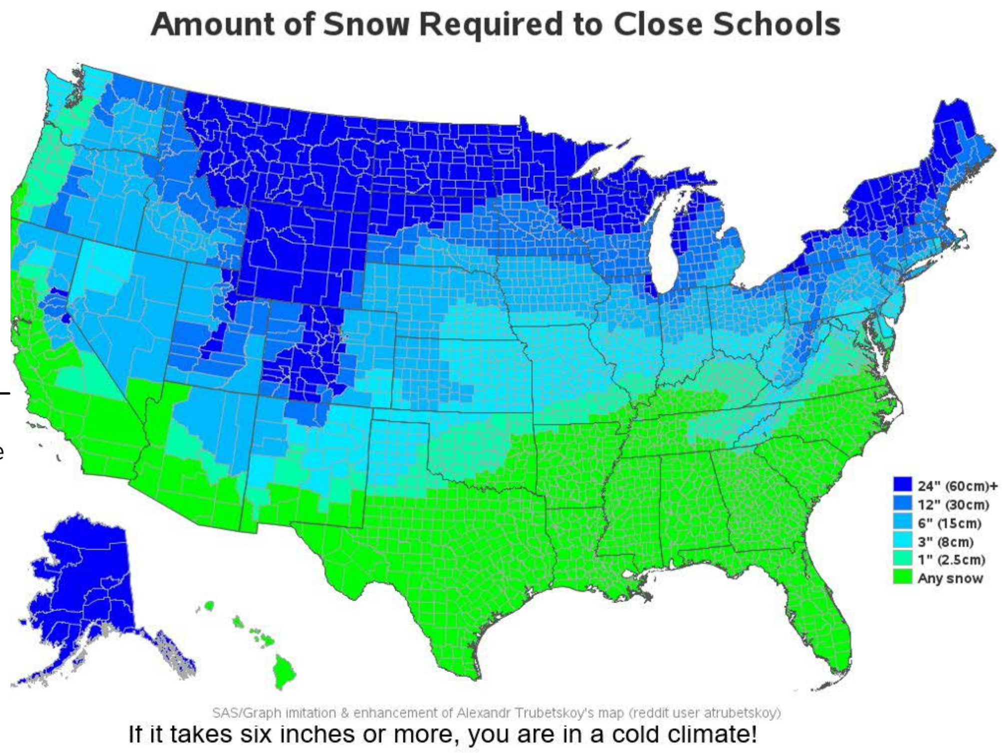
- Somewhat simplified guidance of each of the following:
  - Sizing for heating and cooling loads
  - Sizing for humidity and comfort
  - Considering house, homeowner, ducts, and control strategies
  - **Considering additional humidity control**
  - **Based on climate zone and goals**

Does this sound good to you?

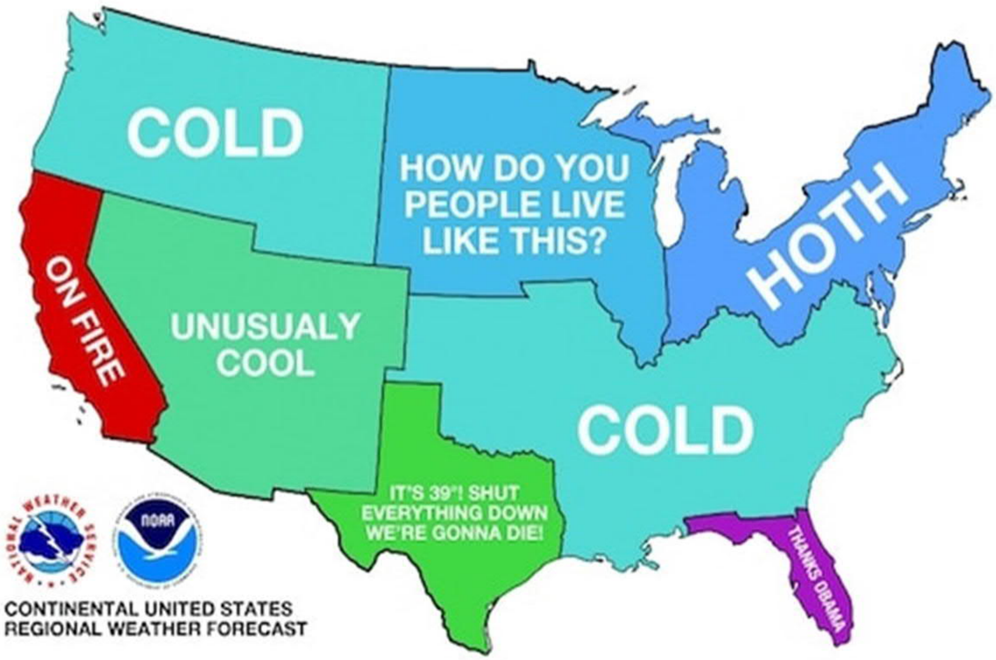


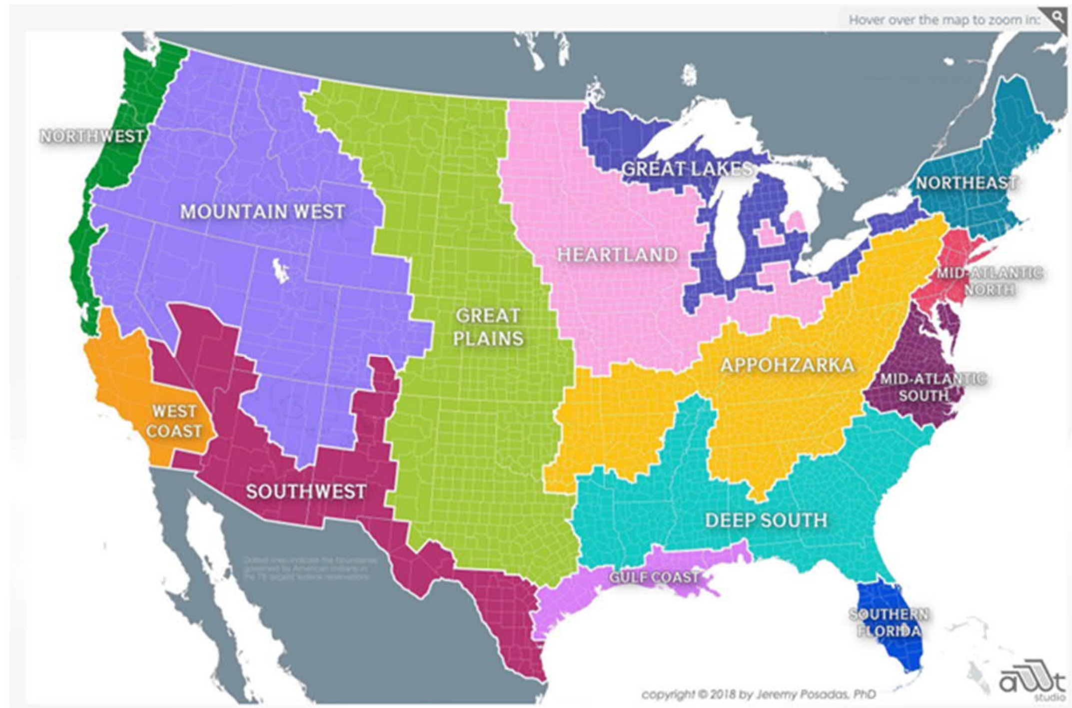
Climate zones reimagined





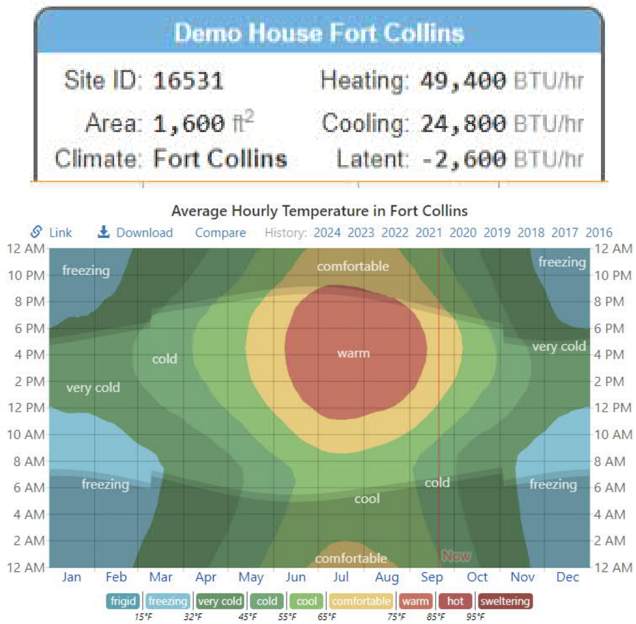
Climate zones reimagined

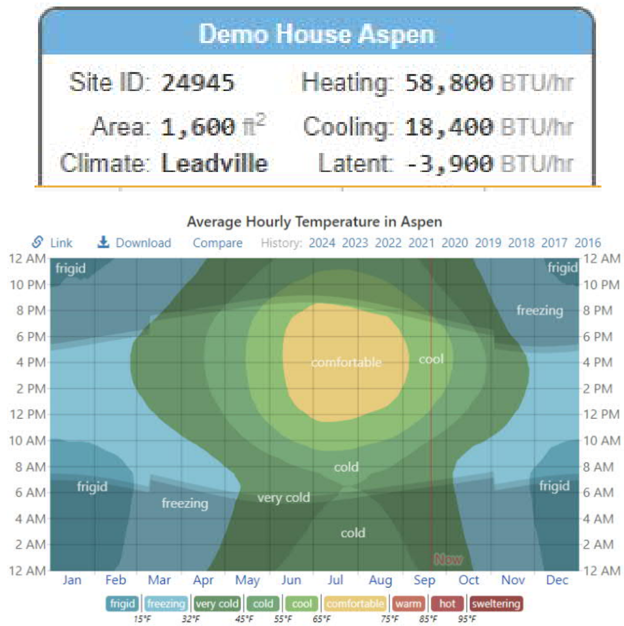


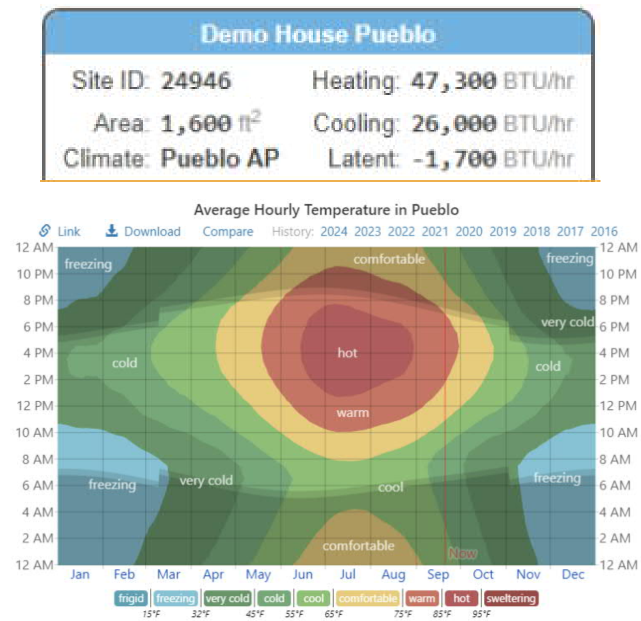


Same house – same heat pump – 3 cities

The Weather Year Round Anywhere on Earth - Weather Spark







Heating load/cooling load = 1.99

Sensible Heat Ratio Over 1.0

Heating load/cooling load = 3.20

Sensible Heat Ratio Way over 1.0

Heating load/cooling load = 1.82

Sensible Heat Ratio Over 1.0

Example Fort Collins House

HVAC SIZING TOOL

Demo House Fort Collins

Site ID:	16531	Heating:	49,400 BTU/hr
Area:	1,600 ft^2	Cooling:	24,800 BTU/hr
Climate:	Fort Collins	Latent:	-2,600 BTU/hr

Building

Conditioned Floor Area	1600	Floors Above Grade	2
Average Wall Height	8.0	Bedrooms	3

Note: **Default insulation level** below is meant to provide a starting point for the house override these default values. Please take care to override where neccessary.

Default Insulation Level	2x4 poorly insulated
Foundation Type	Conditioned Basement
Duct Location	Custom (enter details below)

Custom Duct Location

Attic %	20
Unconditioned Basement or Crawl Space %	0
Conditioned Area %	80

Direction Front Door (House Orientation)	West
Year Built	1950

Overrides

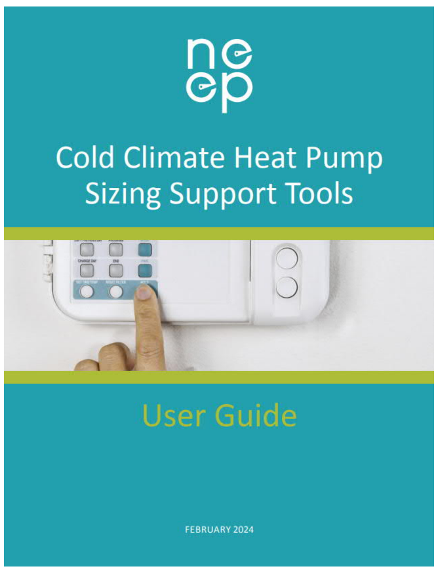
	Default	Rough Equiv	Override	Value
Ceiling U-Value	0.081	(R-11)	R-28	0.034
Floor U-Value	0.368	(R--0.3)	Default	
Wall U-Value	0.240	(R-0.0)	R-11	0.097
Basement Wall U-Value	0.148		Default	
Basement Floor U-Value	0.025		Default	
Slab F-Value	1.180		Default	
Door U-Value	0.500			
Window U-Value	1.000			
Window SHGC	0.870			
Duct Insulation	R-4		Default	
Duct Leakage	Average		Tight	
Winter Infiltration ACH	0.700			
Summer Infiltration ACH	0.400			

NEEP Tool

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

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

READ THIS!!!



On behalf of clean energy and energy efficiency stakeholders, NEEP is pleased to host the Cold Climate Air Source Heat Pump (ccASHP) Product List. This Product List was originally launched in 2015; for more on the background, visit the ASHP Initiative. The list includes ASHP systems that meet the latest version of the ccASHP Specification. The voluntary specification includes requirements for both performance levels and a series of reported performance standards.

Please note that being listed does not necessarily mean a product is appropriate for all cold climate applications. Consumers, contractors, and designers should review building loads, equipment capacities at design temperatures, and other important factors before selecting equipment. Visit NEEP's Installer and Consumer Resources for more information.

Ready to search the list?

Product Type — Central Air Conditioning Hea

Ducting Configuration — All Ducting Configurations

Brand — All Brands

AHRI* or Model# — AHRI, Model or Ur

Refrigerant

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

Potential Eligibility for IRA Tax Credit
- ☐ North (2024)
- ☐ South (2024)
- ☐ CEE Tier 1 Path A (2025)
- ☐ CEE Tier 1 Path B (2025)

Heat Cap. 47°F Rated Btu/h* — 0 to 80000

Heat Cap. 5°F Max Btu/h — 0 to 80000

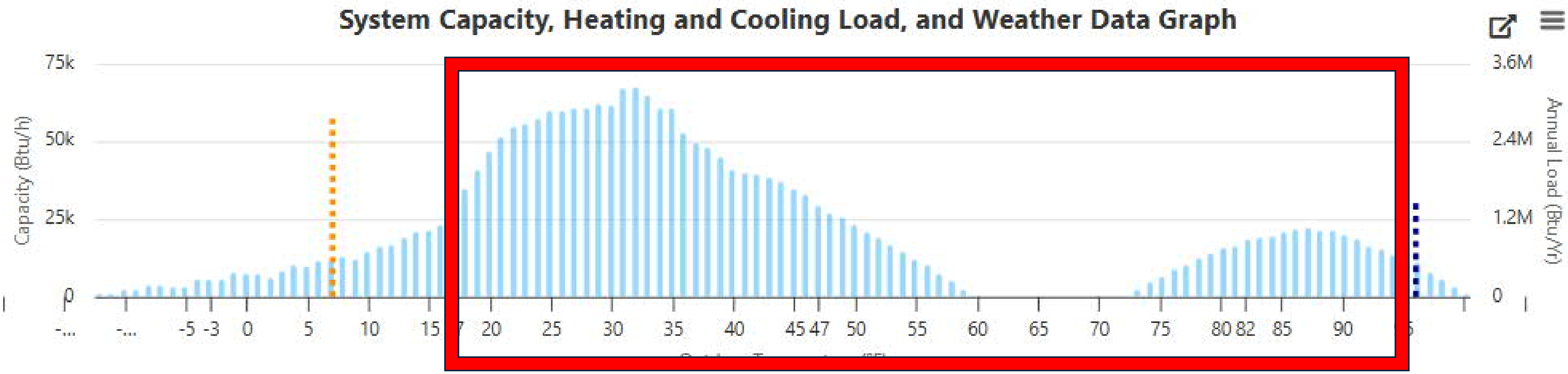
SEARCH THE LIST

Advanced Search - Sizing for Heating and Cooling

NEEP Tool Updates

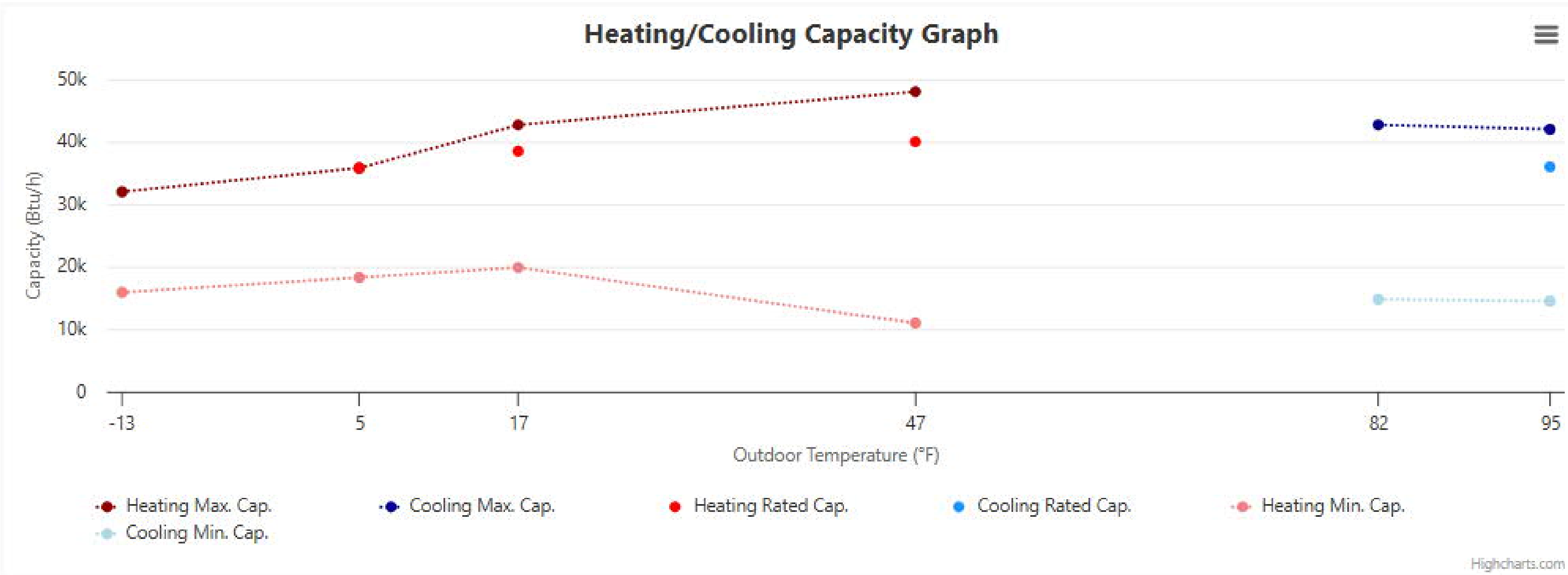
- The Northeast Energy Efficiency Partnership has made updates and added features to the Advanced Sizing for Heating and Cooling Tool in the ccASHP Product List.
- Recorded webinar available!
- https://neep.org/event/using-neeps-ccashp-sizing-tools-product-tutorial

Load x Hours



Visualization Chart Legend	Definition/Importance
Annual Load x Hours (Btu/yr)	On the graph, there is a bar chart in the background indicating the number of load hours a home spends at each outdoor temperature range or "bin." For each bin, this is the home's load (Btu/h) ***times*** the number of hours this temperature occurs annually. It is an indication of how much heating energy is needed each year at various outdoor temperatures. This can help users understand relative impacts of short cycling and backup heating for a given heat pump and home heating load. Generally, the more this bar chart is covered by the modulating zone, the better the heat pump fits the heating load.

Turndown Ratio and Goldilocks Zone



Turn-down Ratio: In a two stage, multi-stage or variable capacity ASHP, this is the ratio of maximum capacity to minimum capacity (e.g., 3.5:1). ASHPs with higher turn-down ratios will operate without cycling for a greater proportion of the heating season, increasing their seasonal efficiency.

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Definitions for switch over temperature / balance point

The balance point is a TEMPERATURE at which switch over 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 or indoor temperature at which the cost to heat the home with the HP is the same or more expensive than the back up heat cost. • Relies on the primary and back up heat fuel cost.
Comfort balance point	• The outdoor temperature at which the homeowner experience discomfort when running the heat pump. • Supply air temperature sensor is an alternative approach.

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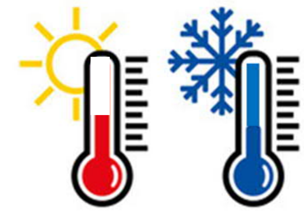
PPT Rest

Any questions so far?

What do you need to consider when…
The heating load is 1.75x the cooling load

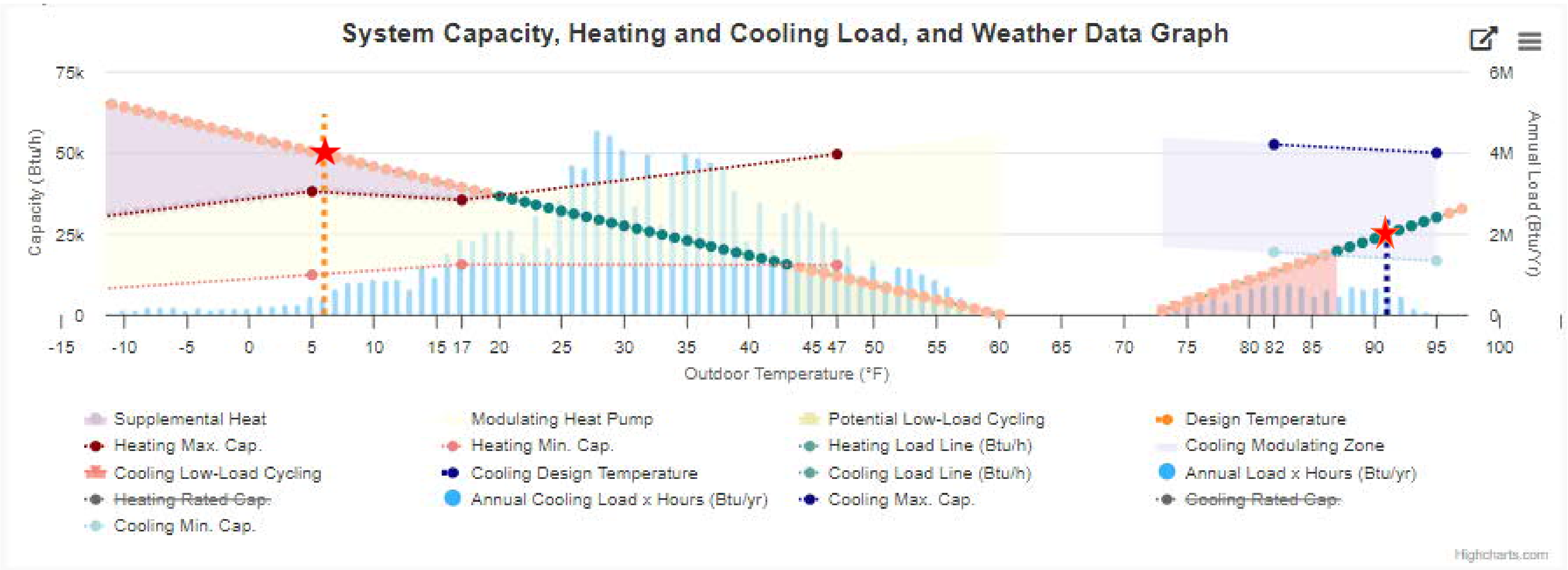


Always communicate when savings are possible with the selected equipment and designed for control strategy

Five Options – Dual Fuel Scenario

1. **Right size**
   1. **Size for cooling**
   2. Let the Heat Pump work for 6 to 10 months of the year – 2 stage or variable capacity heat pump ideal
   3. Switch to supplemental heat based on economics, carbon savings, or comfort
2. Pick a premium heat pump approach
   1. **Great low-load capacity and efficiency at 17°F, 47°F, and 82°F**
   2. **Great turn down ratio at 47°F**
   3. **Good turn down ratio at 5°F, 17°F, 82°F and 95°F**
3. Consider pre-conditioning any intentional ventilation air
   1. Or Weatherize and add an ERV or Humidifier
4. Pay attention to short cycling issues
   1. Over 30% low-load short cycling for both heating and cooling is not ideal
5. **Size to capture all cooling load with a 10% buffer**
   1. **Minimum cooling capacity at least 10% lower than cooling design load and at least below maximum cooling capacity**

4-ton Airquest Heat Pump – Centrally Ducted Unit



4-ton system

Heating load data

Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	20
Minimum Capacity Threshold (°F)	43
Maximum Capacity at Design Temp (Btu/h)	37,783
Percent Design Load Served	76.5%
Annual Heating Load (MMBtu)	111.8
Percent Annual Heating Load Served	86.2%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	15.4
Hours Requiring Supplemental Heat	427
Percent Hours Requiring Supplemental Heat	7.0%
Percent Annual Load Modulating	65.7%
Percent Annual Load with Low-Load Cycling	18.3%

Product Sizing For Cooling

View Oversizing Effects

Definition/Use Cases

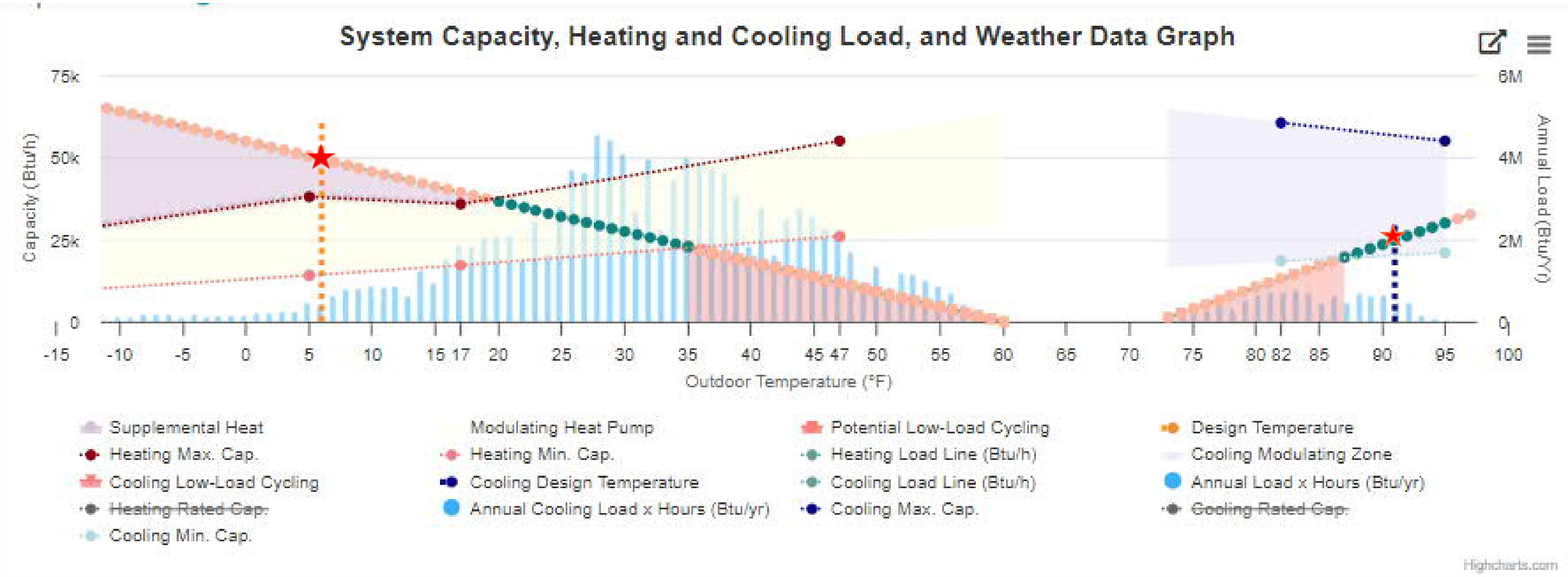
Minimum Capacity Threshold (°F)	87
Maximum Capacity at Design Temp (Btu/h)	50,700
Percent Design Load Served	204.4%
Annual Cooling Load (MMBtu)	11.0

Definitions/Use Cases

Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	29.9%
Percent Annual Load with Low-Load Cycling	69.5%

Cooling load data

4.5-ton Airquest Heat Pump – Centrally Ducted Unit



4.5-ton system

Heating load data

Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	19
Minimum Capacity Threshold (°F)	35
Maximum Capacity at Design Temp (Btu/h)	37,817
Percent Design Load Served	76.6%
Annual Heating Load (MMBtu)	111.8
Percent Annual Heating Load Served	87.9%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	13.5
Hours Requiring Supplemental Heat	372
Percent Hours Requiring Supplemental Heat	6.1%
Percent Annual Load Modulating	45.3%
Percent Annual Load with Low-Load Cycling	39.0%

Product Sizing For Cooling

View Oversizing Effects

Definition/Use Cases

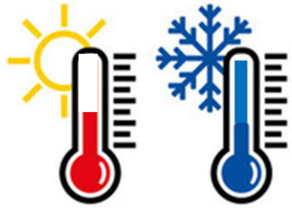
Minimum Capacity Threshold (°F)	87
Maximum Capacity at Design Temp (Btu/h)	56,692
Percent Design Load Served	228.6%
Annual Cooling Load (MMBtu)	11.0

Definitions/Use Cases

Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	29.9%
Percent Annual Load with Low-Load Cycling	69.5%

Cooling load data

What do you need to consider when…
The heating load is 1.75x the cooling load



Always communicate when savings are possible with the selected equipment and designed for control strategy

Four Options –ccHP doing ~95 to 100% heating load

1. All-Electric cold climate heat pump approach (Rated by ENERGY STAR/CEE1)
   1. Size for heating and let the Heat Pump do 95 to 100% of the heating load – **cold climate variable capacity heat pump necessary**
   2. **Look for awesome high capacity maintenance (over 85%)**
   3. Switch to supplemental heat based on capacity balance point
2. Weatherize building
   1. **Try to get heating to cooling load ratio below 1.5**
   2. **Think through ventilation and humidification – an ERV or humidifier may be warranted**
3. Mix and match heat pump solutions use multiple heat pumps
   1. Zone the house (potentially by floor) and install systems per zone
4. Pay attention to short cycling issues
   1. Over 30% low-load short cycling for both heating and cooling is not ideal
   2. **Minimum cooling capacity lower than cooling design load**

MIDEA

Central Air Conditioning Heat Pump (HP)

Singlezone Ducted, Compact Ducted

AHRI Cert #*: **215471421**

Outdoor Unit Model #*: **MO1BU-H60B-2A**

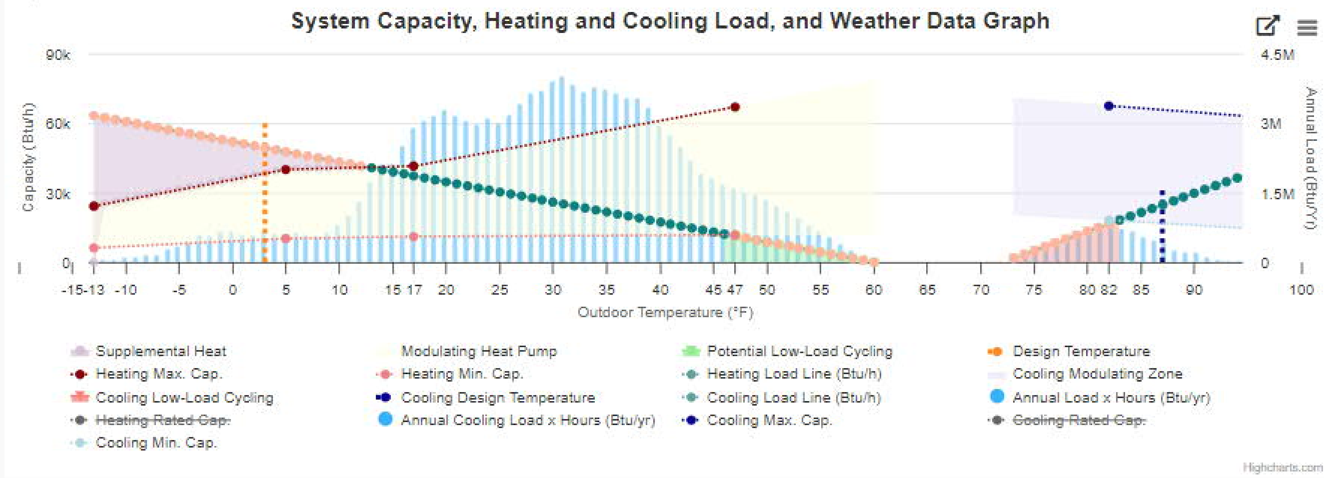
Indoor Model #*: **MDHHS-H60B-2A**

Maximum Heating Capacity (Btu/h) @5°F: **40,000**

Rated Heating Capacity (Btu/h) @47°F*: **60,000**

Rated Cooling Capacity (Btu/h) @95°F*: **58,000**

Capacity Maintenance
40,000/60,000
66%



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	13
Minimum Capacity Threshold (°F)	46
Maximum Capacity at Design Temp (Btu/h)	38,244
Percent Design Load Served	77.4%
Annual Heating Load (MMBtu)	128.5
Percent Annual Heating Load Served	92.0%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	10.3
Hours Requiring Supplemental Heat	274
Percent Hours Requiring Supplemental Heat	4.1%
Percent Annual Load Modulating	81.2%
Percent Annual Load with Low-Load Cycling	9.5%

Product Sizing For Cooling

View Oversizing Effects

Definition/Use Cases

Minimum Capacity Threshold (°F)	83
Maximum Capacity at Design Temp (Btu/h)	65,769
Percent Design Load Served	265.2%
Annual Cooling Load (MMBtu)	8.8

Definitions/Use Cases

Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	35.4%
Percent Annual Load with Low-Load Cycling	64.6%

MIDEA MDH Series

Central Air Conditioning Heat Pump (HP)

Singlezone Ducted, Compact Ducted

AHRI Cert #*: **215471428**

Outdoor Unit Model #*: **MO1HU-H60B-2A**

Indoor Model #*: **MDHHS-H60B-2A**

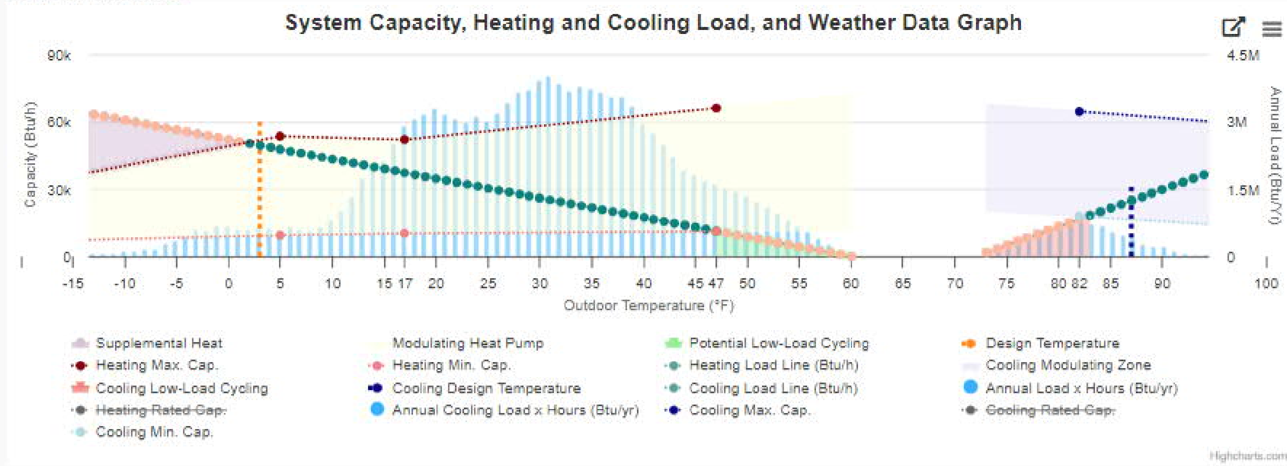
Maximum Heating Capacity (Btu/h) @5°F: **53,500**

Rated Heating Capacity (Btu/h) @47°F*: **60,000**

Rated Cooling Capacity (Btu/h) @95°F*: **55,000**

Capacity Maintenance
53,500/60,000
89%

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	2
Minimum Capacity Threshold (°F)	47
Maximum Capacity at Design Temp (Btu/h)	51,744
Percent Design Load Served	104.7%
Annual Heating Load (MMBtu)	128.5
Percent Annual Heating Load Served	96.7%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	4.3
Hours Requiring Supplemental Heat	92
Percent Hours Requiring Supplemental Heat	1.4%
Percent Annual Load Modulating	87.2%
Percent Annual Load with Low-Load Cycling	8.2%

Product Sizing For Cooling

View Oversizing Effects

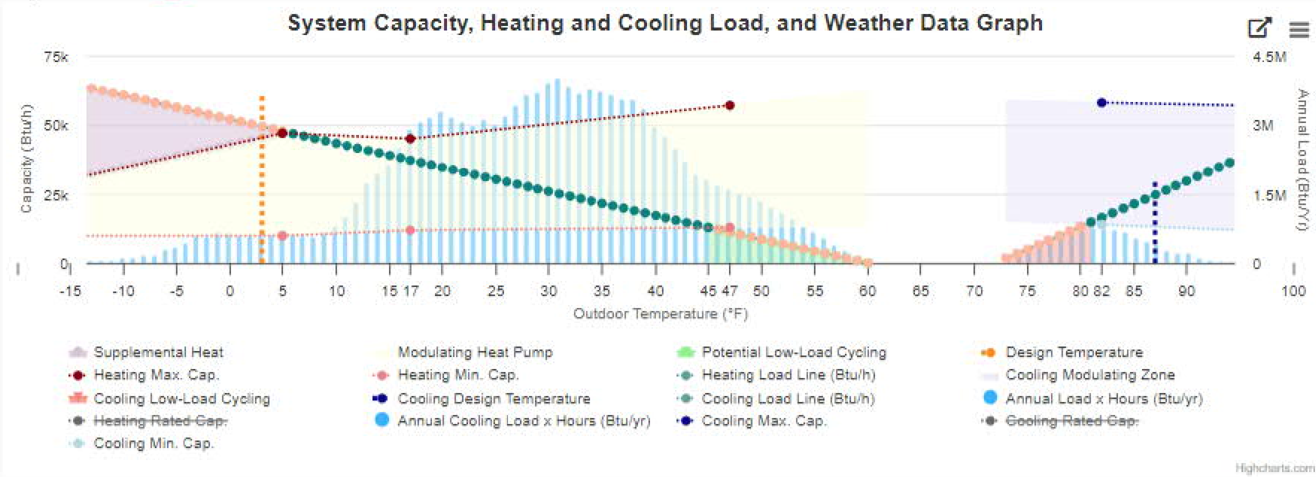
Definition/Use Cases

Minimum Capacity Threshold (°F)	83
Maximum Capacity at Design Temp (Btu/h)	62,769
Percent Design Load Served	253.1%
Annual Cooling Load (MMBtu)	8.8

Definitions/Use Cases

Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	35.4%
Percent Annual Load with Low-Load Cycling	64.6%

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	6
Minimum Capacity Threshold (°F)	45
Maximum Capacity at Design Temp (Btu/h)	45,341
Percent Design Load Served	91.8%
Annual Heating Load (MMBtu)	128.5
Percent Annual Heating Load Served	95.3%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	6.1
Hours Requiring Supplemental Heat	144
Percent Hours Requiring Supplemental Heat	2.1%
Percent Annual Load Modulating	83.0%
Percent Annual Load with Low-Load Cycling	10.8%

Product Sizing For Cooling

View Oversizing Effects

Definition/Use Cases

Minimum Capacity Threshold (°F)	81
Maximum Capacity at Design Temp (Btu/h)	57,615
Percent Design Load Served	232.3%
Annual Cooling Load (MMBtu)	8.8

Definitions/Use Cases

Percent Annual Cooling Load Served	100.0%
Percent Annual Load Modulating	52.5%
Percent Annual Load with Low-Load Cycling	47.5%

NEEP ccASHP LISTED

CANAIR

Central Air Conditioning Heat Pump (HP)

Multizone All Non-Ducted

AHRI Cert #*: **215449733**

Outdoor Unit Model #*: **4C28MC648H21**

Indoor Model #*:

Maximum Heating Capacity (Btu/h) @5°F: **47,000**

Rated Heating Capacity (Btu/h) @47°F*: **49,000**

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

Capacity Maintenance
47000/49,000
96%

Sensible vs Latent Heat and "right sizing."

Sensible Heat Ratio

- Ratio of sensible vs latent heat loads in the building

Demo House Fort Collins			
Site ID:	16531	Heating:	49,400 BTU/hr
Area:	1,600 ft^2	Cooling:	24,800 BTU/hr
Climate:	Fort Collins	Latent:	-2,600 BTU/hr

- For this building, the latent load for cooling is -2,600/24,800. This means the sensible heat ratio is over 100%

Sensible Heat Fraction

- This is the capability of the equipment you are selecting.
- Modern, high SEER2 heat pumps (and ACs) have much higher sensible heat fractions when compared to older systems.
- When Latent load is negative or the sensible heat ratio is over 100%, you don't need to worry specifically about the **SHF, but higher is better i**n such a dry climate. It will be important as we will use the SHF in our capacity adjustments

Considerations for Colorado

- Fort Collins is at a high elevation – 5,003 ft, and Leadville is even higher 9,943 ft, – Capacities need to be derated!
- BUT – As a dry climate, you can take half the "left over" latent capacity and add it back to the sensible capacity
- Front Range is a dry climate – use dry coil adjustment
- You may not have to adjust if OEM instructions state that no adjustment is needed
  - Lennox does this
  - Mitsubishi does this

Altitude Adjustment Factors Cooling Evaporator with Air-Cooled Condenser				
Altitude (Feet)	**Total Capacity**		**Sensible Capacity**	
	Wet-Coil	**Dry-Coil**	**Wet-Coil**	**Dry-Coil**
Sea Level	1.00	1.00	1.00	1.00
1,000	0.99	0.98	0.97	0.98
2,000	0.98	0.97	0.94	0.97
3,000	0.98	0.95	0.91	0.95
4,000	0.97	0.94	0.88	0.94
5,000	0.96	0.92	0.85	0.92
6,000	0.95	0.90	0.82	0.90
7,000	0.94	0.89	0.80	0.89
8,000	0.94	0.87	0.77	0.87
9,000	0.93	0.86	0.74	0.86
10,000	0.92	0.84	0.71	0.84
11,000	0.91	0.82	0.68	0.82
12,000	0.90	0.81	0.65	0.81

1. Interpolation and extrapolation of values published by the Carrier Corp (**Engineering Guide for Altitude Effects**, 1967).
2. Use wet-coil values for sensible heat ratios (SHR) less than 0.95

Sensible Heat Fraction (CSHR, SHF, or S/T)

Sensible heat fraction or CSHR (capacity sensible heat ratio) is a cooling systems sensible heat to total heat removal ratio.
Manufacturer data will show equipment sensible heat fraction as a decimal noted as S/T and is found with a total capacity (TC)

This system was “Rated” as a 33,000 BTU cooling heat pump

	TC	32872	33166	33460	33755
	S/T	0.86	0.99	1.00	1.00
	PI	3.35	3.35	3.35	3.35

32,872 btu X 0.92 (altitude adjustment) X 0.86 = 26,008 btu sensible cooling capacity

Sensible cooling capacity adjustments

N2.3.5 *Sensible Cooling Capacity* Adjustment

After sizing for total *capacity* and qualifying latent *capacity*, the *designer* shall be permitted to recalculate the *sensible cooling capacity* by adding half of the excess latent *capacity* indicated by the OEM *performance data* to the *sensible cooling capacity*. The adjusted *sensible cooling capacity* shall be equal to or more than 90% of the sensible load (0.90 *size factor*).

TC	32872	33166	33460	33755
S/T	0.86	0.99	1.00	1.00
PI	3.35	3.35	3.35	3.35

32,872 btu X 0.92 (altitude adjustment) X 0.86 = **26,008 btu**

What is the excess latent capacity?

32,872 x 0.86 = 28,270
Excess latent capacity =
32,872 – 28,270 = 4,602
Half of that is 2,301

Adjustment: Add ½ of the latent capacity back

26,008 btu
+ 2,301 btu
28,309 btu Adjusted Sensible Cooling

Efficiency considerations

- Coefficient of Performance (COP) is an instant efficiency rating at a specific outdoor temperature.
- **Equipment tends to have highest COPs when running somewhere between its minimum capacity and its rated capacity when mild or warm.**
- The temps listed in Extended Performance Data that are important to look at will differ based on your climate zone

Performance Specs

Heating / Cooling	Outdoor Dry Bulb	Indoor Dry Bulb	Unit	Min	Rated*	Max
Cooling	95°F	80°F	Btu/h*	14,600	58,000	63,000
			kW	1.2	5.8	6.78
			COP	3.57	2.93	2.72
Cooling	82°F	80°F	Btu/h*	18,200	-	67,500
			kW	1	-	4.16
			COP	5.33	-	4.76
Heating	47°F	70°F	Btu/h*	11,800	60,000	67,000
			kW	0.78	4.75	5.17
			COP	4.43	3.7	3.8
Heating	17°F	70°F	Btu/h*	11,100	40,000	41,500
			kW	1.5	4.41	4.96
			COP	2.17	2.66	2.45
Heating	5°F	70°F	Btu/h*	10,200	40,000	40,000
			kW	1.45	5.33	5.33
			COP	2.06	2.2	2.2
Heating	-13°F	70°F	Btu/h*	6,200	-	24,200
			kW	1.37	-	4.36
			COP	1.33	-	1.63

Dan’s quick and dirty guidance!

	Upper Heartland, Great Leaks, Northeast	Lower Heartland, Appohzarka, Mid-Atlantic	Mountain West	Great Plains
Size to:	Cooling load*	Balanced	Balanced+	Balanced+
SHF guidance	At or lower than SHR	At or lower than SHR	Higher is better	Higher is better
Efficiency Guide	COP at Min to Rated capacity at 17ºF, 47ºF, 82ºF, 95ºF	COP at Min to Rated capacity at 5ºF, 17ºF, 47ºF, 82ºF	COP at Min to Rated capacity at 5ºF, 17ºF, 47ºF, 82ºF	COP at Min to Rated capacity at 17ºF, 47ºF, 82ºF, 95ºF
Weatherization recommended	Yes, for all-electric	Possibly	Yes, for all-electric	Yes, for all-electric
Low-load Short Cycling (LLSC)	Watch for heating and cooling LLSC	Watch for heating and cooling LLSC	Watch for cooling LLSC	Watch for cooling LLSC
Ventilation air	HRV or ERV	ERV and/or Dehumidifier	ERV or Humidifier	HRV or ERV & Humidifier
Turndown ratio @ 47ºF and 82ºF	2+	2.5+	3+	2.25+
Dry Mode	Maybe	Maybe	No	No

*May go balanced if the homeowner is looking to decarbonize.
+May go cooling for dual fuel, may go heating if ccASHP for electrification

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Any questions so far?

Sizing and Ducts

The Duct Assessment Protocol

This process is going to be tested in a Building America Research Project that CEE is about to kick off with our partners

1. Homeowner interview (comfort, air delivery, IAQ, bills, etc..)
2. Does the existing system have central AC?
3. Homer Simpson tests

   Does warm air come out of the registers you'd expect in heating mode?

   Cool air in cooling mode?

   Did you use a smoke puffer or TP to see if exhaust fans are working?
4. TESP
5. Visual inspection of ducts
6. Register and duct accounting
7. Using TEC Smart Calculator or Manclark Table to project if a new system with specified airflow is likely to work.

60,000 btu 90% GAS FURNACE *VS* 3-TON AC

WHICH NEEDS MORE AIRFLOW?

THEN, WE'LL COMPARE TO A 2.5-TON HP

GAS FURNACE AIR FLOW

Natural Draft Furnaces

100 CFM per 10,000 BTU of rated BTU input

Induced Draft Furnaces

130 CFM per 10,000 BTU of rated BTU input

Condensing Furnaces

150 CFM per 10,000 BTU of rated BTU input

A 60,000 BTU/hr. condensing gas furnace would need:

150 X 6 (60,000/10000) = 900 cfm

Note the higher the efficiency, the more airflow it needs.

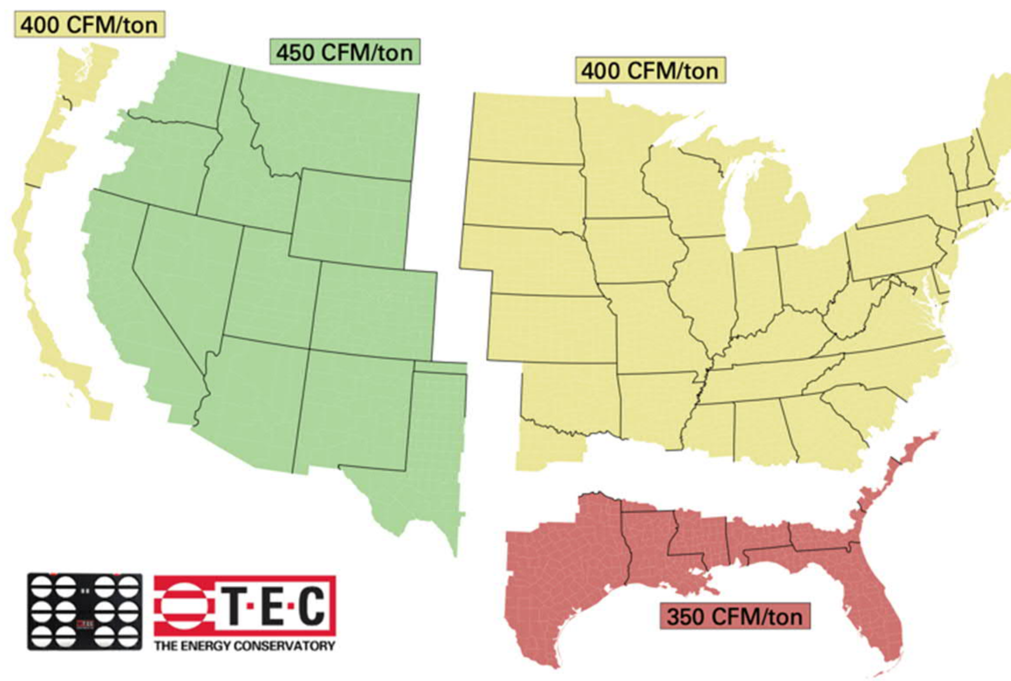
Air Conditioner Air Flow

Single and Two speed ACs

- 400 - 450 CFM per Ton

Variable Capacity Heat Pumps

- 325 – 450 CFM per Ton



A 36,000 BTU/hr. AC would need:

- 450 X 3 tons = 1350 cfm

NOTE: Rule of Thumb ALERT

Variable Capacity Heat Pump Air Flow

Single and Two speed ACs

- 400 - 450 CFM per Ton

Variable Capacity Heat Pumps

- 325 – 450 CFM per Ton

A 30,000 BTU/hr. VCHP would need:

- <u>450 X 2.5 tons = ~1125 cfm</u>
- <u>450 x 3 tons = 1350 cfm</u> Bonus 3-ton math

Furnace needs 900 CFM

AC needs 1350 CFM

VCHP needs ~1125 CFM

In THIS CASE, will a heat pump fit with the ductwork?

60 kbtu 90% GAS FURNACE and 2-TON AC

Sizing a Heat Pump for Heating First

VCHP is 3-Ton

60 kbtu Gas furnace needs 900 CFM

2-Ton AC needs 900 CFM

3-Ton VCHP with worst case air flow needs 1350 CFM

Options for Sizing to Ductwork

Measured Approach

- Calculate needed airflow based on size
- TESP and Airflow measurements with existing equipment
- Forecast future TESP and Airflow with new system
- Build duct alterations into bid if necessary

Visually Assessed Approach

- Look up total airflow needed for future system
- Inspect ducts and account for likely airflow to each room and whole house
- Identify any “bad actors” in the duct system
- Prescriptively improve filter slot, size, and type

For homes with comfort or IAQ issues or intend to use no backup heat at all, do both. If home fails visually assessed approach, do both!

Register Accounting and Visual Assessment

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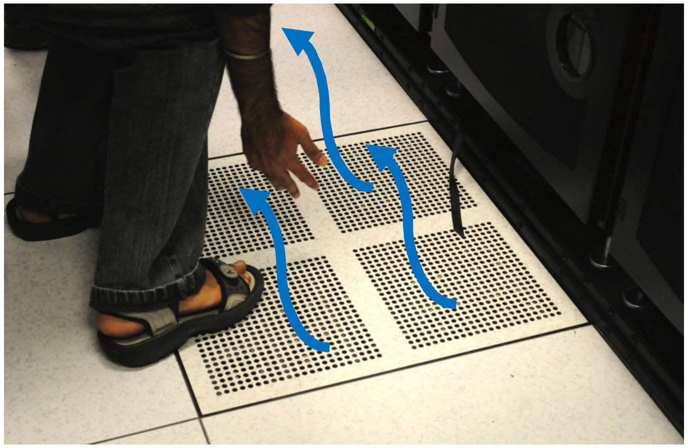
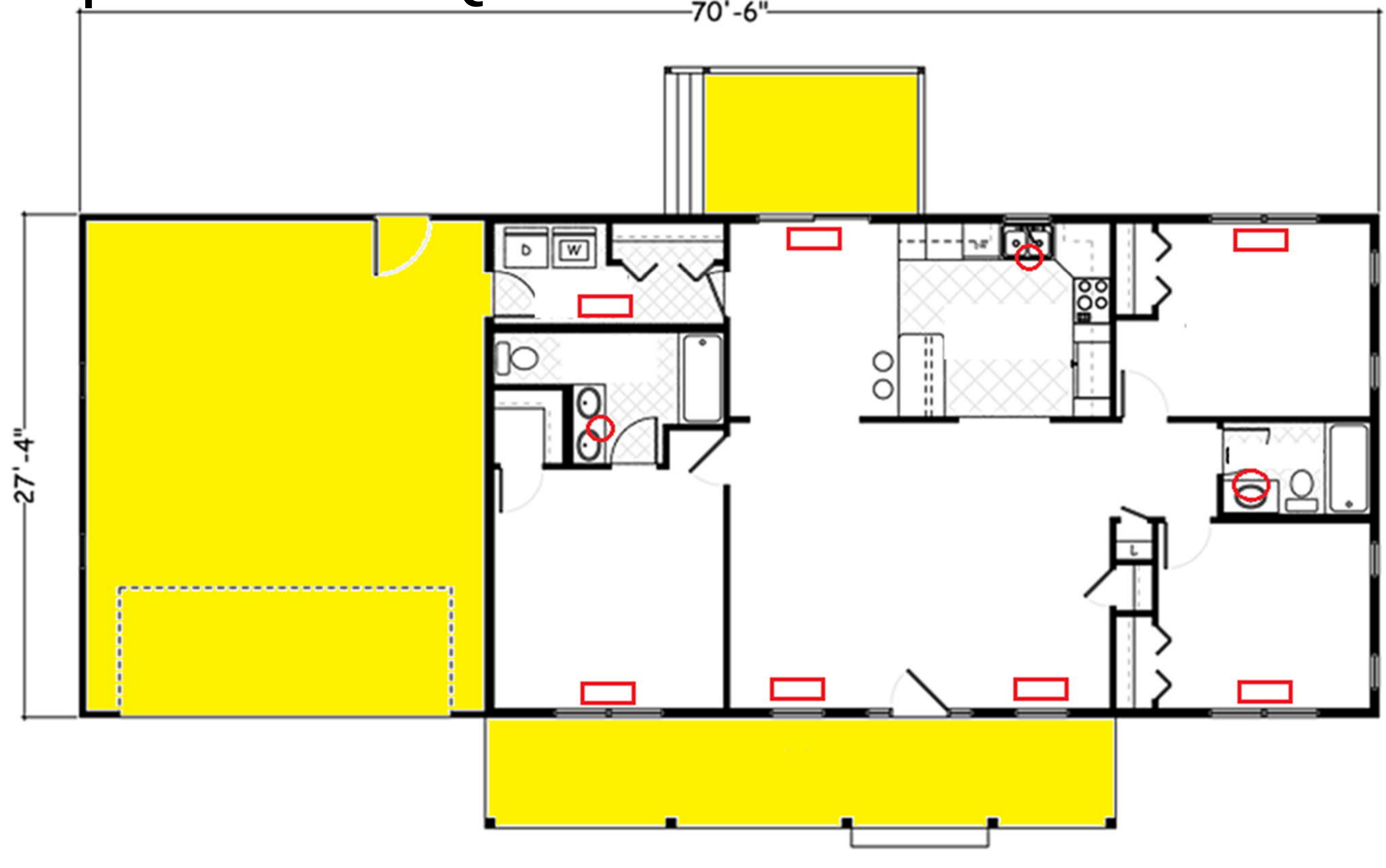
"Homer Simpson test" - Does warm air come out when calls for heating? Does cool air come out when calls for air conditioning?



Images courtesy Wikimedia Commons

Example 1324 SQFT home:



Count the registers

- 12 Total Supply Registers
  - 3 Counter Toe Kicks under sinks
  - 9 6x10 registers
    - Are all registers open?
  - 6” hard pipe to each supply
  - 1 or 2 return grilles (depending on age of home!!)
    - Filter grille or open return?
- Common Duct Sizing
  - 6” Flex or Hard Pipe (10 cfm less for flex)
  - 16 x 24 Return

FIELD DUCT SIZING CHART

ROUND DUCT SIZE ESTIMATE

Flexible Duct

Duct Size	Design Airflow
5"	50
6"	75
7"	110
8"	160
9"	225
10"	300
12"	480
14"	700
16"	1000
18"	1300
20"	1700

Flex duct = .05" on most metal duct calculator

Round Metal Pipe

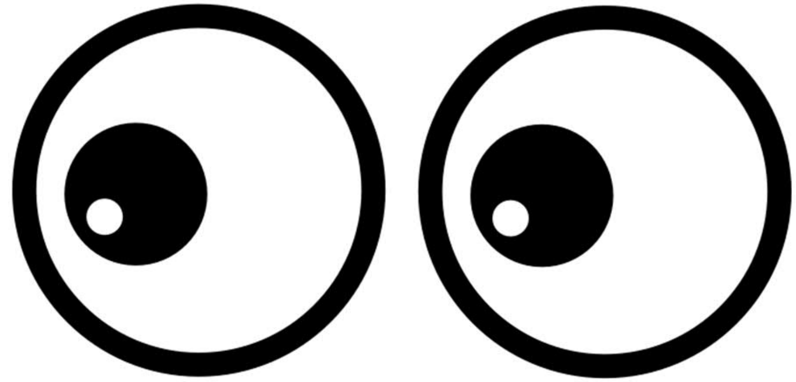
Duct Size	Design Airflow
5"	50
6"	85
7"	125
8"	180
9"	240
10"	325
12"	525
14"	750
16"	1200
18"	1500
20"	2000

Round metal pipe = .06" on most metal duct calculators

RECTANGULAR DUCT SIZE ESTIMATE

Design	Duct Height - Net inside dimension in inches								
CFM	4"	CFM	6"	CFM	8"	CFM	10"	CFM	12"
60	**6x4**	60	**4x6**	90	**4x8**	120	**4x10**	150	**4x12**
90	**8x4**	110	**6x6**	160	**6x8**	215	**6x10**	270	**6x12**
120	**10x4**	160	**8x6**	230	**8x8**	310	**8x10**	400	**8x12**
150	**12x4**	215	**10x6**	310	**10x8**	430	**10x10**	550	**10x12**
180	**14x4**	270	**12x6**	400	**12x8**	550	**12x10**	680	**12x12**
210	**16x4**	320	**14x6**	490	**14x8**	670	**14x10**	800	**14x12**
240	**18x4**	375	**16x6**	580	**16x8**	800	**16x10**	950	**16x12**
270	**20x4**	430	**18x6**	670	**18x8**	930	**18x10**	1100	**18x12**
300	**22x4**	490	**20x6**	750	**20x8**	1060	**20x10**	1250	**20x12**
330	**24x4**	540	**22x6**	840	**22x8**	1200	**22x10**	1400	**22x12**
		600	**24x6**	930	**24x8**	1320	**24x10**	1600	**24x12**
		650	**26x6**	1020	**26x8**	1430	**26x10**	1750	**26x12**
		710	**28x6**	1100	**28x8**	1550	**28x10**	1950	**28x12**
		775	**30x6**	1200	**30x8**	1670	**30x10**	2150	**30x12**
40	**21/2 x10**			1300	**32x8**	1800	**32x10**	2300	**32x12**
70	**21/2 x14**			1400	**34x8**	1930	**34x10**	2450	**34x12**
150	**21/2 x30**			1500	**36x8**	2060	**36x10**	2600	**36x12**
		100	**31/2 x14**			2200	**38x10**	2750	**38x12**
		220	**31/2 x30**			2350	**40x10**	2900	**40x12**
								3050	**42x12**

Rectangular sheet metal duct = .07" on most metal duct calculators



Size the return grille(s)

NOTE: Rule of Thumb ALERT

Image courtesy Bruce Manclark

SYSTEM CFM	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700
Gross Area Return Size (Sq. Inches)	300	350	400	450	500	550	600	650	700	750	800	850

A GENERAL RULE: 2 cfm per sq. inch

Examples:

3 tons: 1200 CFM/2 = 600 sq inches

2 tons: 800 CFM/2 = 400 sq inches

So, if that’s the case…

- 12 runs of 6” (not considering surface of registers)
  - 900 CFM capability for flex
  - 1020 CFM for hard pipe

- 1 return duct size 16 x 24
  - 384 sq inches
  - 768 CFM capability

Going from 900 to 1350 CFM flow, does the accounting look like these ducts would work?

CAN THE EXISTING DUCT SYSTEM HANDLE THE AIRFLOW?

Summary

Check existing airflow needs and/or **TESP FIRST** – it may be a moot point!

Include register accounting as one method to check for appropriate duct sizes

Duct modifications may have to be made, or equipment size adjusted

If including a new filter rack? GO WITH 4” FILTER BOX

Measure existing airflow, is it close?

Remember variable speed will seldom be on the maximum fan flow

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Any final questions?

Static Resources

[Consortium for Energy Efficiency ASHP QI Resources]

Guides developed and available

Contractor facing:
- System design with existing heating
- Weatherization for contractors
- Duct retrofit decision guide
- Controls for HP with secondary heating
- ASHP decision matrix and system design
- Sizing Considerations for Heating and Cooling

Homeowner facing:
- Weatherization for homeowners
- You installed an ASHP, now what
- Controls for HP with secondary heating for homeowners
- Homeowner Decision Matrix and System Design Guide

Read and Bookmark This!

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Cold Climate Heat Pump Sizing and Selection

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Scope | Description | Success | Climate | Training | Compliance | More

Scope

Size and select a cold climate heat pump:

- Understand the goals of the homeowner.
- Determine a sizing approach based on those goals.
- Choose a system configuration.
- Perform heating and cooling load calculations using ACCA Manual J.
- Determine target heating and cooling capacities using ACCA Manual S (3rd edition) and/or other methods.
- Select a cold climate heat pump that meets heating capacity goals without excessive cycling in heating or cooling.

See the Compliance Tab for links to related codes and standards and voluntary federal energy-efficiency program requirements.

A properly sized cold climate heat pump can meet 100% of a home's heating load in nearly any location in the United States

Last Updated: 2024-05-14

THANK YOU

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www.mncee.org