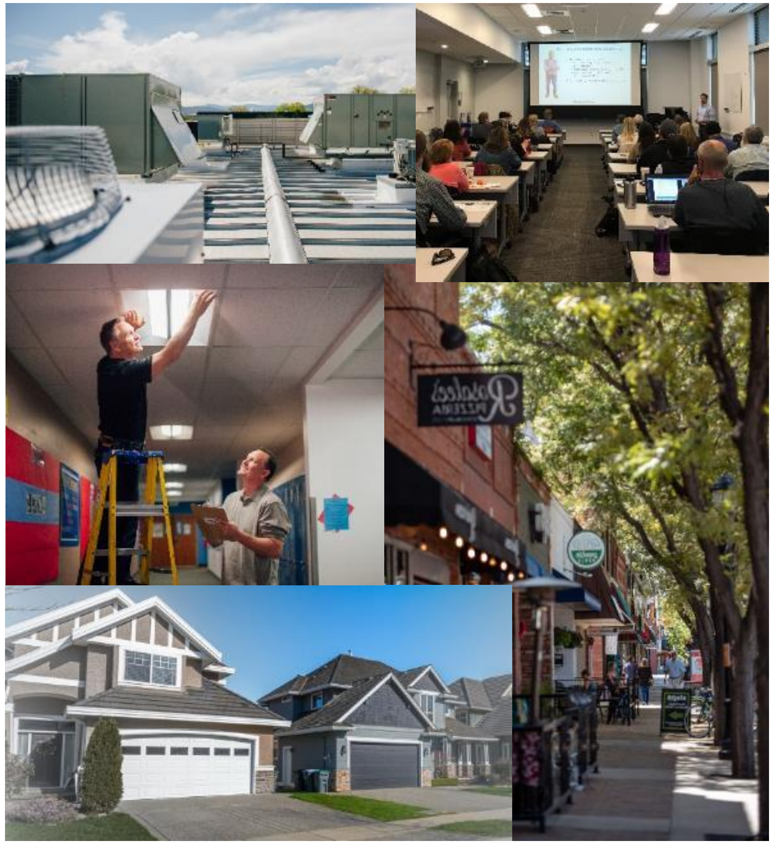
Efficiency Works™

Estes Park | Fort Collins | Longmont | Loveland

2024 Heat Pump Training

October 23, 2024

Efficiency Works overview

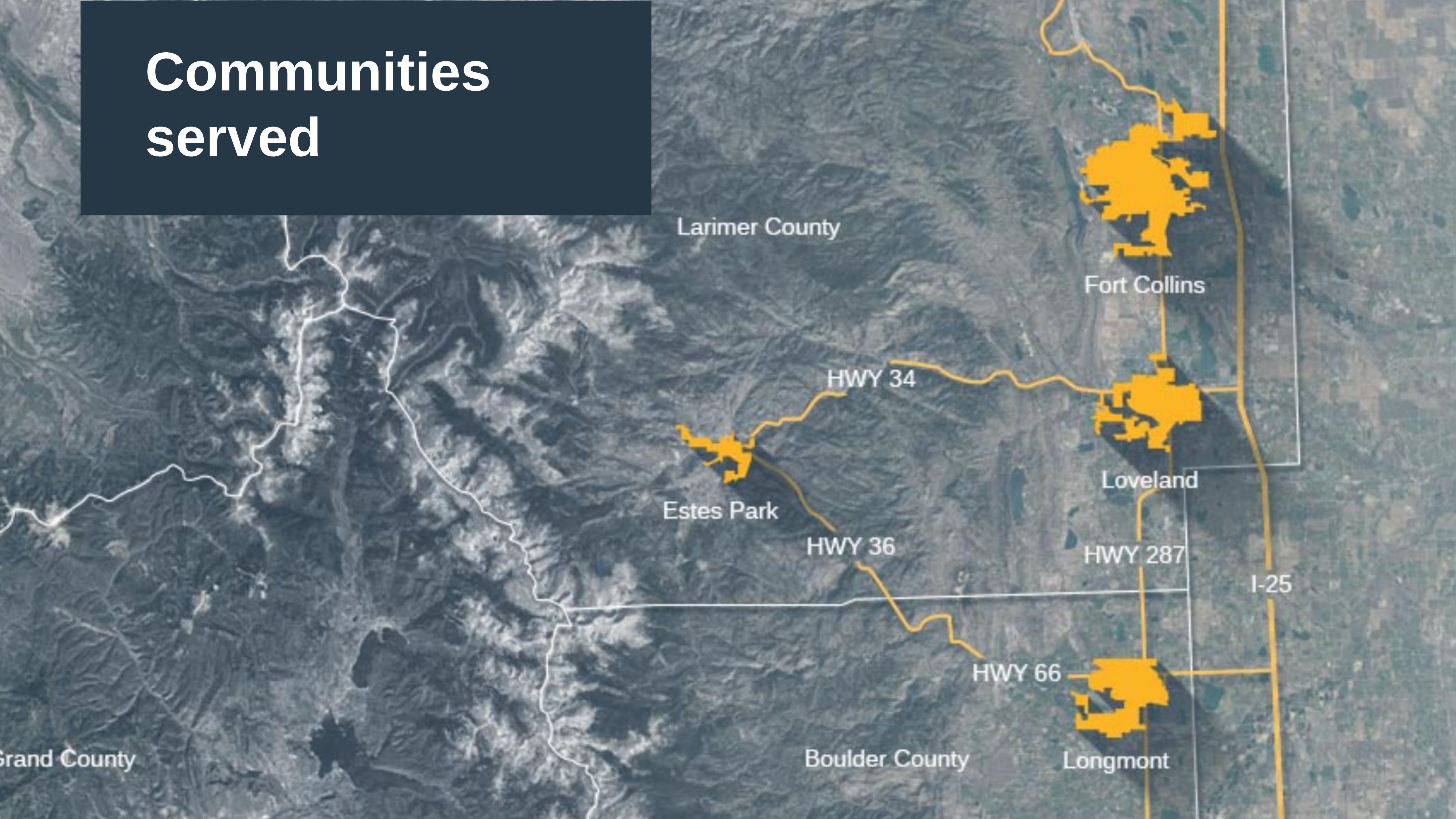


What is Efficiency Works?

- Efficiency Works unites the energy and water efficiency offerings of the northern Colorado utilities of Estes Park Power and Communications, Fort Collins Utilities, Longmont Power & Communications, Loveland Water and Power and Platte River Power Authority.

- The most sustainable way to use energy is to use as little as necessary to meet your needs. Efficiency Works offers home and business energy advising to help you save energy, water and money.

Communities served



Preapproval reminder

Preapproval process

Step 1)

Submit a rebate preapproval application prior to beginning work.

Step 2)

The EW team to review and declare a decision within 2 - 4 business days.

This new process will also include the Efficiency Works Homes team calling the customer to verify project details prior to granting preapproval.

Ex details:

- Confirm relationship to service provider (Are you working with ABC Heating and Cooling?)
- Project scope
- Projected cost
- Projected timelines

Preapproval reminder cont.

Preapproval process

Step 3)

Once an application has been preapproved, a notification will go out to the service provider.

Step 4)

The service provider moves forward and completes the work.

Step 5)

When completed, the service provider returns to their portal to complete the Project Update*.

Step 6)

If the application meets all programmatic specifications the rebate will be approved.

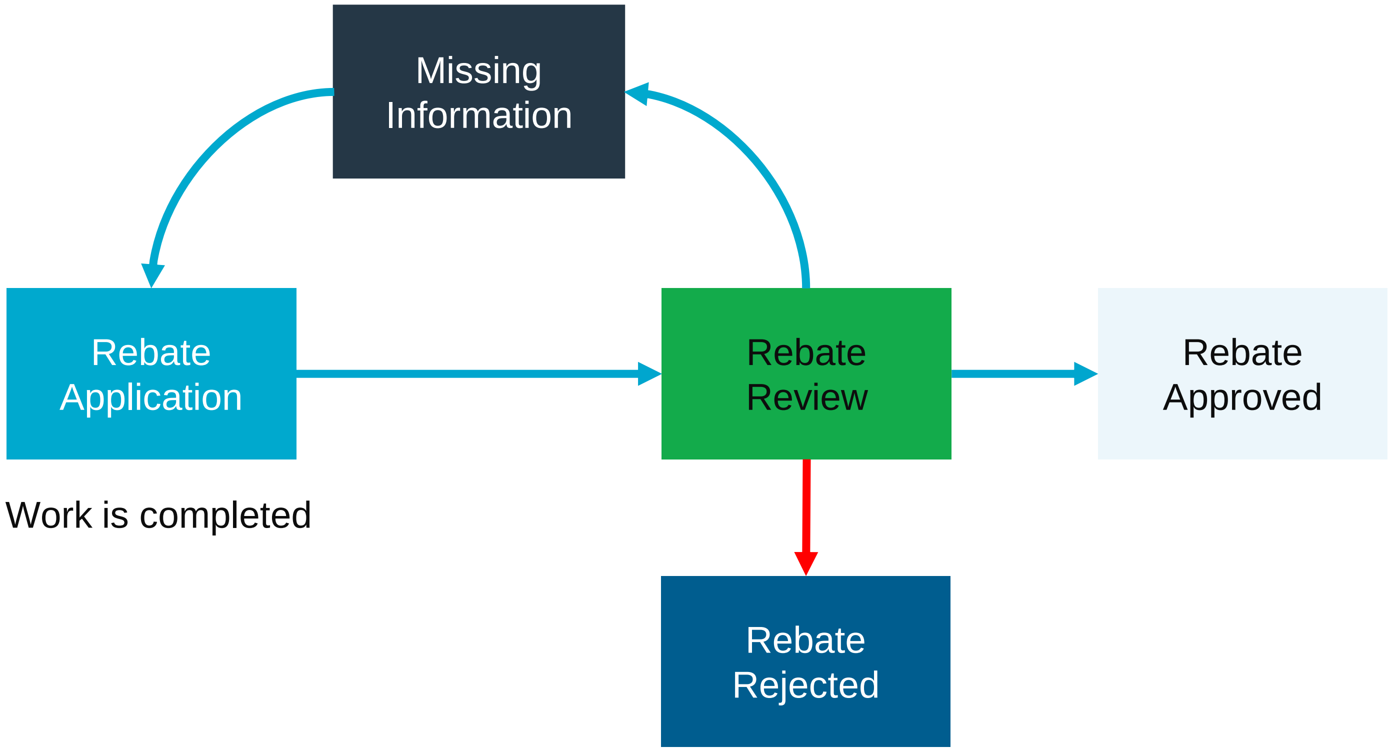
**Any variance of more than 10% of the original preapproved amount will have to be preapproved again or the project will be capped at 110% of the original amount.*

Legacy application process

Service Provider Forms

Efficiency Works Forms

Submit and review for final payment

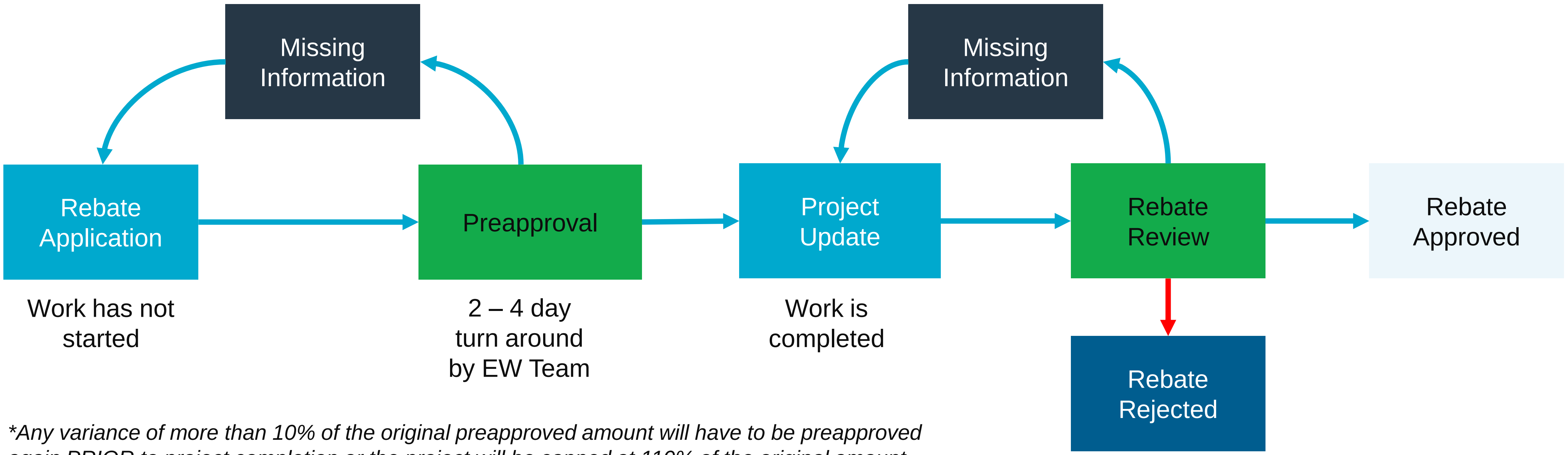


New preapproval process

Service Provider Forms

Efficiency Works Forms

Submit for preapproval



**Any variance of more than 10% of the original preapproved amount will have to be preapproved again PRIOR to project completion or the project will be capped at 110% of the original amount.*

Preapproval reminder cont.

How it works

Efficiency Works Homes resource center

These are our online resources for you to utilize as a listed Efficiency Works Homes Service Provider. Our goal is to provide you up to date and valuable resources to utilize for the program. If you have any questions, please reach out to program staff.

Quick Tips

Rebates shall be applied for within 45 days of receiving project payment from the customer. Once a rebate is approved payment should be received within 3-4 weeks.

Eligibility check
Customers must meet the below requirements to be eligible for a rebate:

- Be a residential electric customer of Estes Park Power & Communications, Fort Collins Utilities, Longmont Power & Communications or Loveland Water and Power.
- Occupy a single-family detached home, attached townhome, or multifamily units (4 or fewer units per building) in our utility partner territories. New construction and mobile homes are not eligible to participate in the Efficiency Works Homes program.
- For Window and Insulation and Air rebates customer must have a completed Efficiency Works Homes Assessment.

Submit Rebate Application

Rebates | Program Guide | Marketing | Other

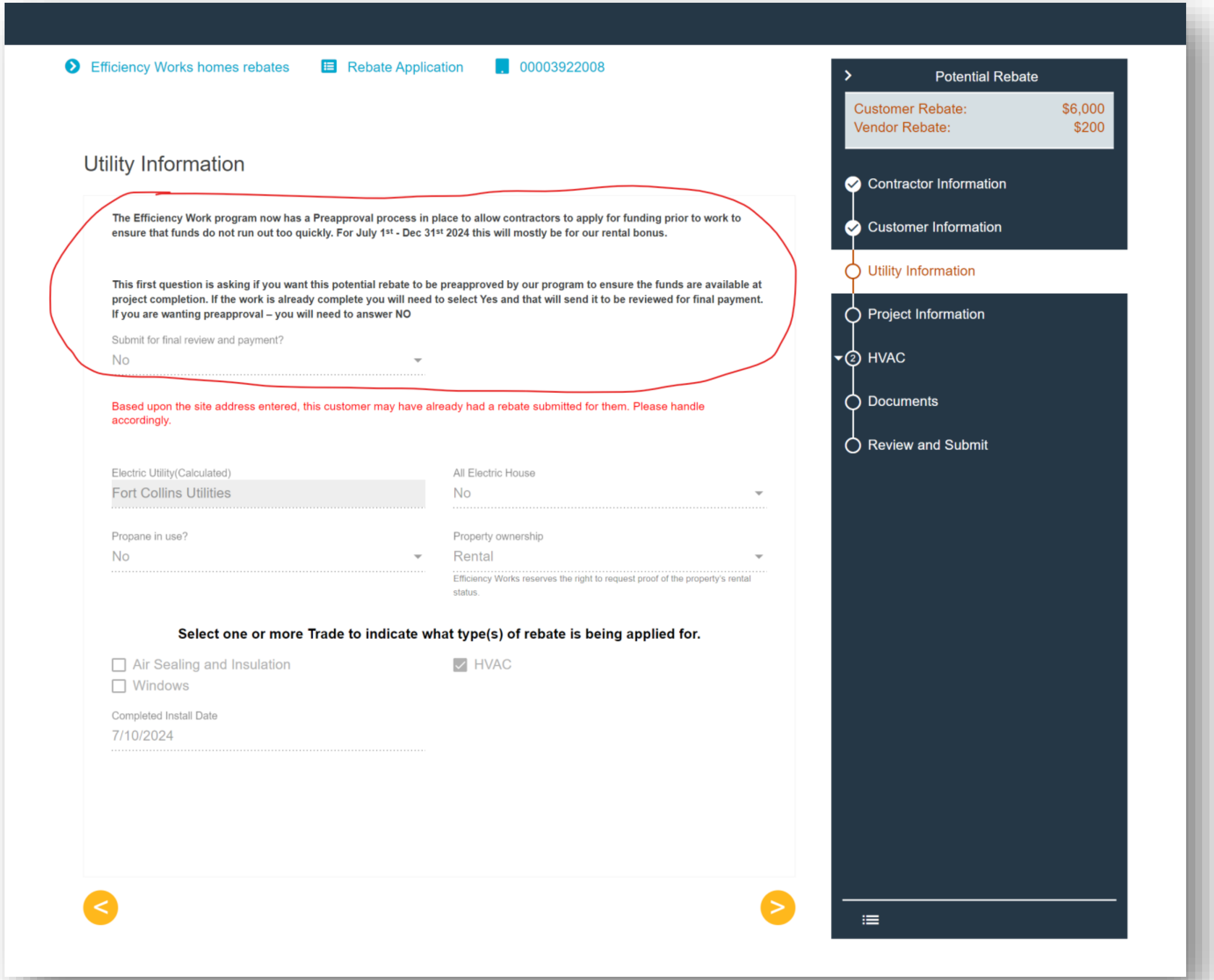
How to apply for rebates

We have created videos to show how to walk through the rebate application process per trade. If you have any additional rebate related questions, please contact the Program Manager at homes@efficiencyworks.org.

How to apply for preapproval video
EPIC loans video
Efficiency Works Homes service provider Orientation video
How to apply for a rebate and required documentation
HVAC rebate example
How to fill out the Certificate of Completion
How to apply for the Unmatched Heat Pump rebate
EW Combustion Safety Test Summary Steps
Setting up the Worst Case Depressurization
EW Combustion Safety Protocol
How to Apply for the Radon fan rebate
Windows rebate example
Ins & As rebate example
Contractor takes rebate example
AC in cold weather rebate example
Landlord gets check rebate example
How to Measure Static Pressure
How to use the Energy Conservatory Flow Plate

Preapproval reminder cont.

How it works



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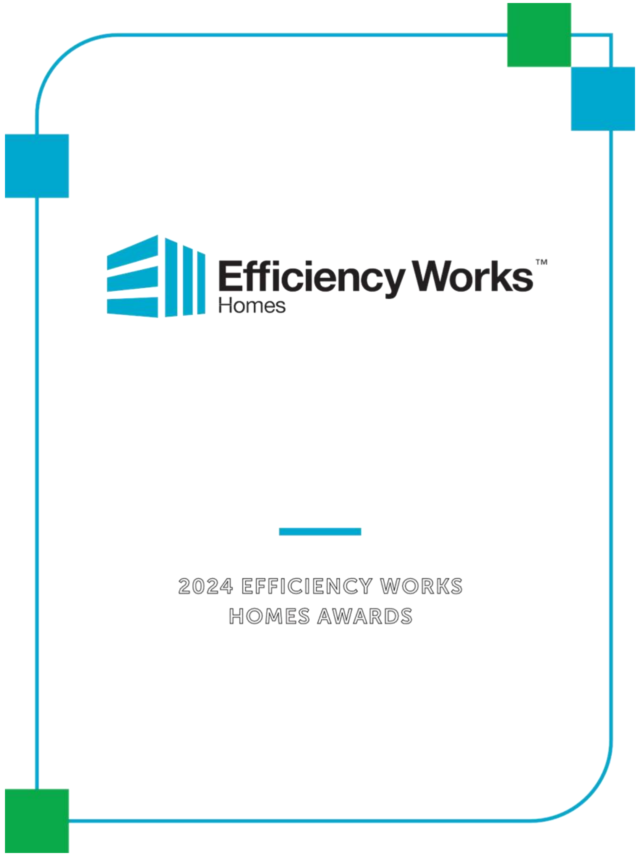
Service Provider Social

Efficiency Works will provide a catered dinner, and there will be a CASH bar

- Raffled door prizes
- Service provider appreciation gift
- Service provider awards
- Upcoming 2025 program updates



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Details

Date: November 21, 2024

Time: 4:30 PM to 6:00 PM

Location: Grimm Brothers

Scott’s departure

Lifting all ships

- I began working in the Efficiency Works program in 2014 as a CLEAResult Technical Field Specialist focused on contractor support/training.
- In 2018, I joined the PRPA team as the Efficiency Works Assessment and Retrofit Program Manager.
- 2024 I have decided to return to the contractor training world (Blue Sky Training)

It has been a pleasure and an honor to work with all of the service providers in the program. Keep up the great work.

My personal email: scottsuddreth@gmail.com

To connect with the program moving forward:
homes@efficiencyworks.org
970-229-5650

Agenda

8:00 am Breakfast

8 am – 9:45 First part of training (EW Hp requirements/Man J - 1.5 hours)

9:45 – 10:00 am – Break

10:00 – 12:00 pm Second part of training (HP Sizing/Duct Considerations - 2 hours)

12:00 – 12:45 pm Lunch (45 minutes)

12:45 – 2:00 Work Force New/Info

2:00 - 2:15 break

2:15 - 4:00 Panel Calculations

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Center for Energy and Environment

PRPA HVAC Training 2024

Making air source heat pumps (ASHPs) work for you, your customers, and PRPA

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

Soon to be a Colorado resident!

We're a mission-driven non-profit that loves to partner!

Learn more about Center for Energy and Environment in CO

What type of work we do

Technical trainings

Pilot/Program Management

- Design/Implementation
- Equity/Income-Qualified
- Commercial/Multi-family/Residential
- Energy Advising/Customer Experience

Who we have worked for

City and County of Denver

Platte River Power Authority

Xcel Energy

Gunnison

BELCO

Who we are members of

SWEEP

EEBC

Where we can be found

www.mncee.org

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Based in Minnesota with an expanding Colorado-focused team

Who is Center for Energy and Environment in CO?

Gabrielle Rinck

Program Implementation Manager- Colorado

Based in Colorado Springs, Gabrielle is responsible for the implementation and delivery of programs and pilots in Colorado

grinck@mncee.org

Robin Osindele

Energy Advisor- Electrification

Based in Englewood, Robin works with equity priority commercial building owners, contractors, and community-based organizations to advance electrification

rosindele@mncee.org

Dan Wildenhaus

Senior Technical Manager- Training and Consulting Services

Soon to be a Colorado resident!

dwildenhaus@mncee.org

And growing…

Center for Energy and Environment

Ideas move at the speed of revolution. People and programs move at the speed of evolution; until now… We are CEE

What we'll cover today

- Efficiency Works program requirements and examples
- Load calcs for Front Range
- Heat Pump sizing and selection for Front Range
- Heat Pump sizing for ductwork
- Rapid deployment assessments – AKA "30 Minutes or Less"
- Specifications and projected changes
- New Tools and Resources
- Electric Panel Assessments
- Bonus material – time permitting
- YOUR questions

Platte River Power Authority HVAC Installation Requirements

Load calculations and efficiency minimums

Center for Energy and Environment

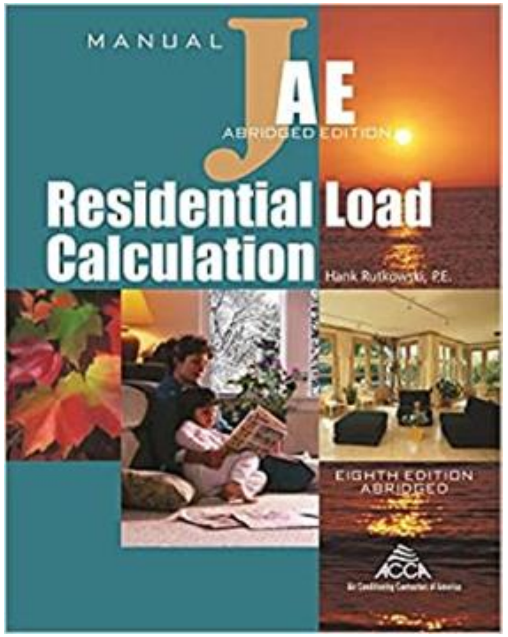
Center for Energy and Environment

Doing Load Calcs

Specific to Front Range climate

Load Calculations

- Must perform Manual J v7 or equivalent
  - Must use ASHRAE math
  - Must be capable of inputting low-e glazing
    - Alternatively, must be able to adjust SHGC to reflect low-e
  - Must be capable of calculating heating and cooling load
  - Must be capable of block load and room-by-room



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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

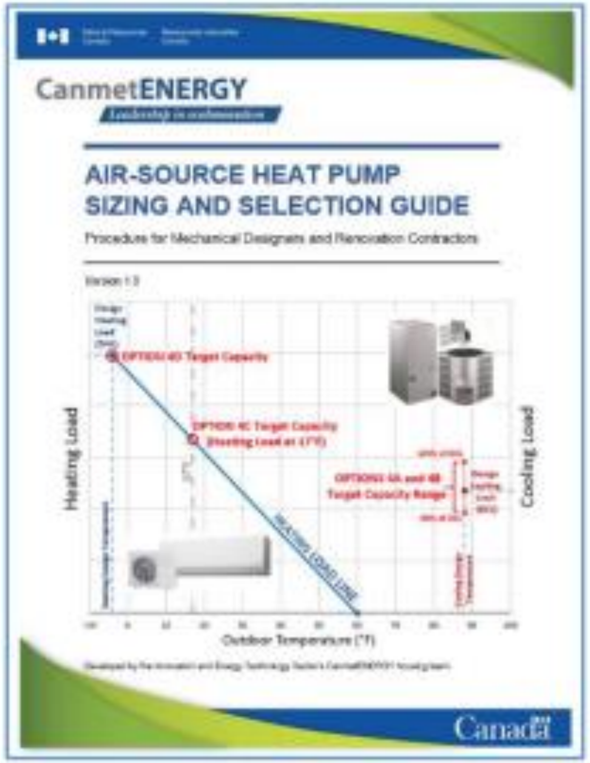
- Accurate for whole house and zoned systems
- Required by some code jurisdictions
- Provides necessary sizing data
- Meets PRPA requirements
- Works with measureQuick, PNNL QI tool, and ASHRAE 221

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			✓	?

Can we size based on existing equipment size?

- Short answer: NO
- Longer answer: The folks at National Resources Canada (NRCAN) have determined that as a last resort, contractors can divide the existing BTU output by 1.33 to get a more realistic size, only if:
  - No comfort issues
  - No weatherization since original sized



https://natural-resources.canada.ca/sites/nrcan/files/canmetenergy/pdf/ASHP%20Sizing%20and%20Selection%20Guide%20(EN).pdf

Manual J and Equivalent Approaches

ACCA Approved

Cool Calc Manual J

MiTek WRIGHTSOFT

Elite Software

EnergyGauge
Energy and Economic Analysis Software

Amply
Amp up your heat pump business

conduit tech

Equivalent – versions may/may not be ACCA Approved

HVAC SIZING TOOL

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

HVAC Designers of Canada – Verified F280 Software

LoopCAD
HeatCAD

Canadian
F280 compliant
Not free

h2x

European
Getting ACCA approved
Great for hydronic

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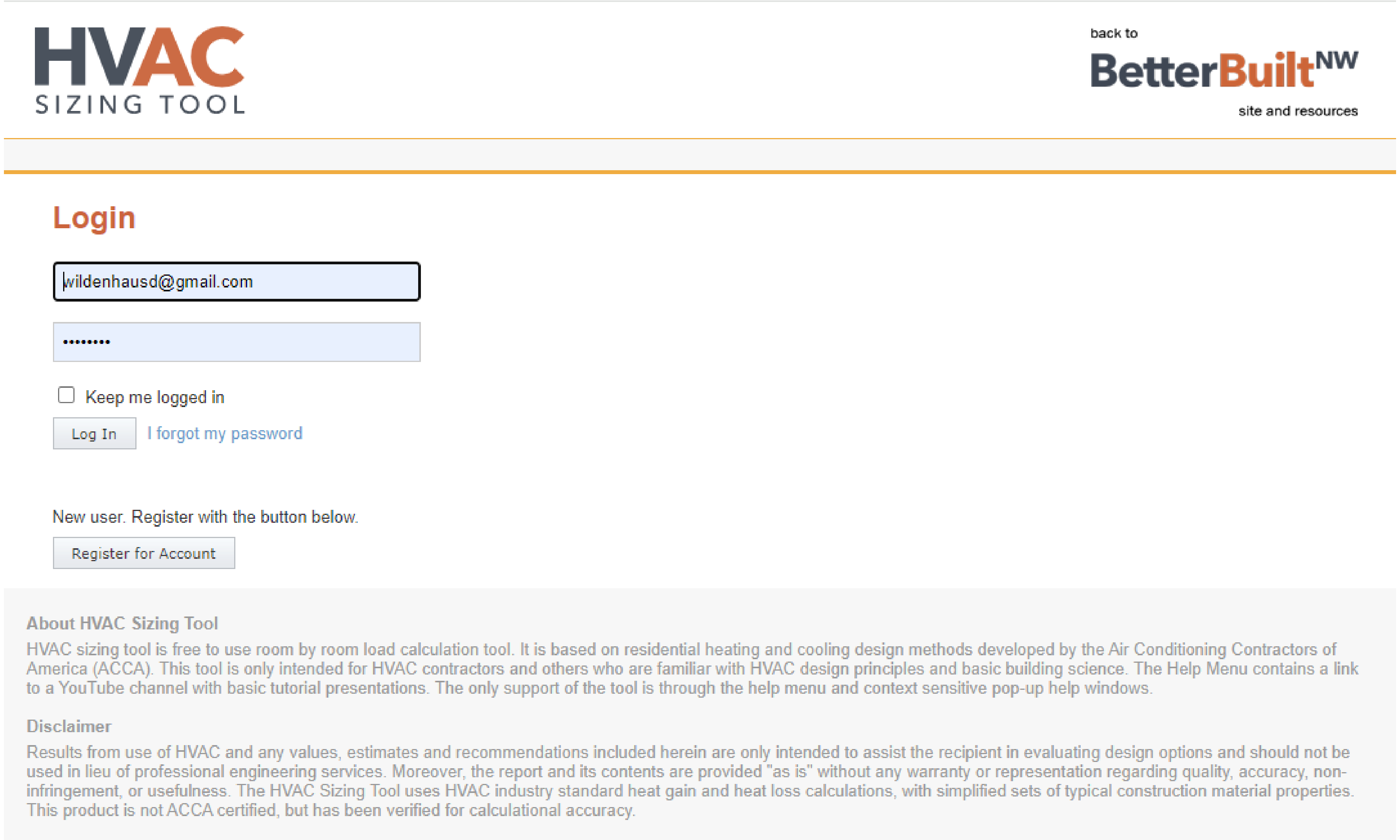
Tool used in today's training



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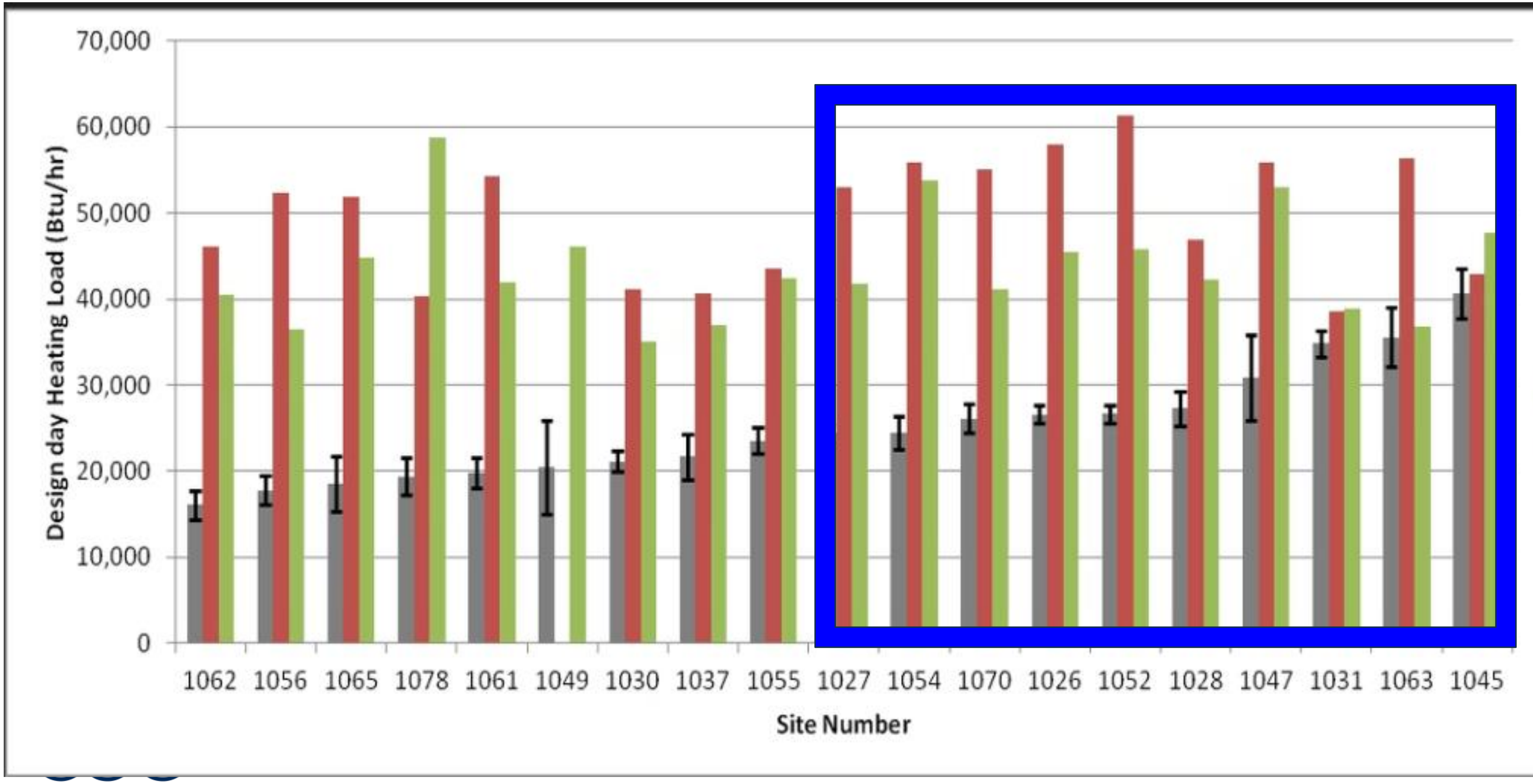
https://hvac.betterbuiltnw.com/Account/Login.aspx

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

Local Design conditions

- **Design Temperature is not the coldest day or hottest day of the year**
- **Winter Design Conditions: It only gets colder than this <u>0.4 to 1%</u> of the time!**
- **Ft Collins:**
  - Winter Design Condition is 6°F
  - Summer Design 91°F with 62°F wet bulb
    - Summer: I don't care about what the design temp is, I want it cool now!

Note: Internal temps for sizing: ACCA presets

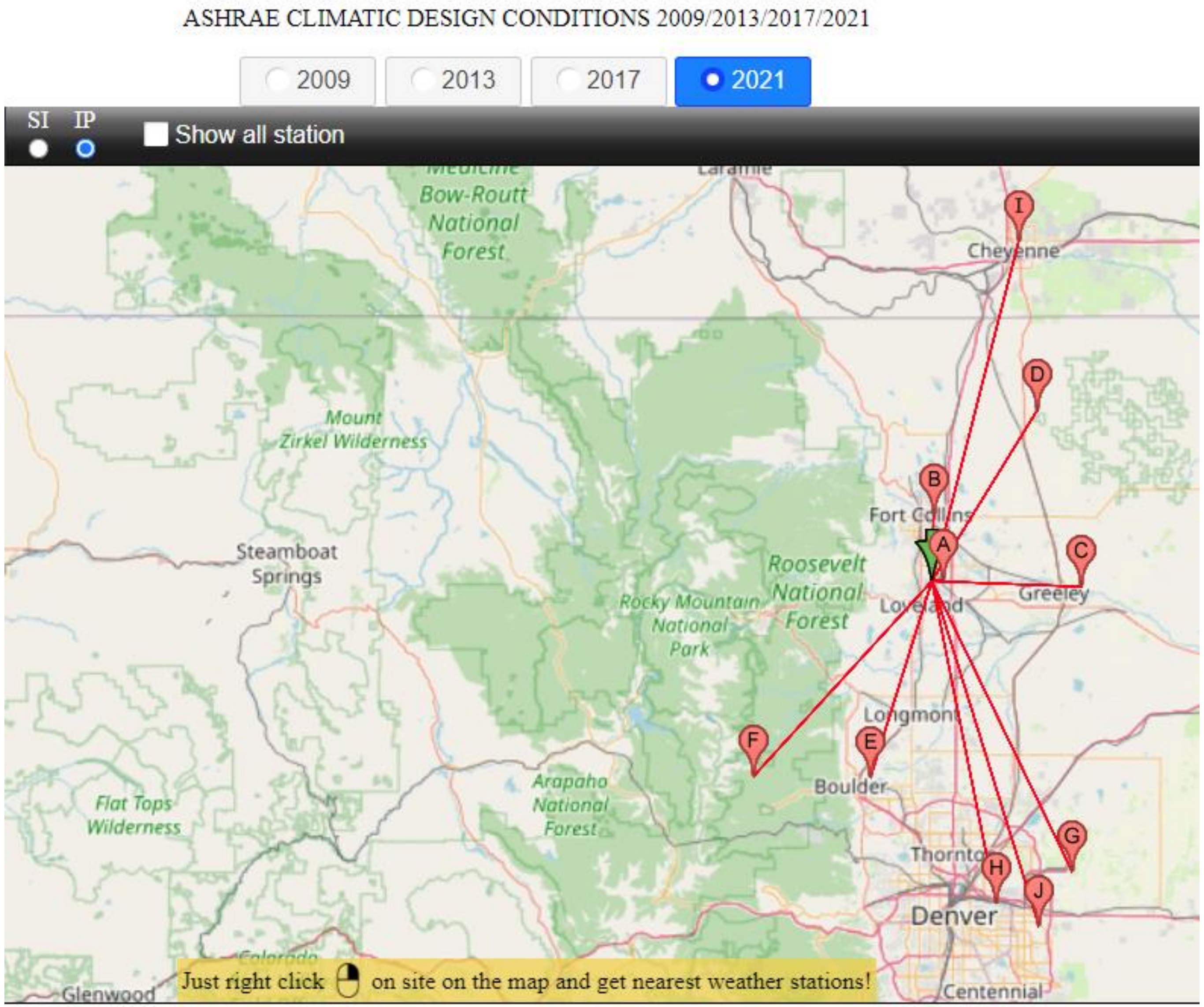
Summer/cooling – 75°F

Winter/heating - 72°F

https://www.fcgov.com/building/hvac-requirements

ASHRAE Climatic Design Conditions 2021

https://ashrae-meteo.info/v2.0/index.php?lat=39.833&lng=-104.658&place=%27%27&wmo=725650



General ASHRAE Design Conditions

2021 ASHRAE Handbook - Foundamentals (IP)

NORTHERN COLORADO, CO, USA (WMO: 724769)

Lat:**40.450N** Long:**105.017W** Elev:**5015** StdP: **12.22** Time zone:**-7.00 (NAM)** Period:**94-19** WBAN:**94035** Climate zone:**5B**

Annual Heating, Humidification, and Ventilation Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		WSF
			99.6%			99%			0.4%		1%				
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
12	**0.0**	**5.5**	**-7.9**	**4.3**	**2.2**	**-1.6**	**6.1**	**12.6**	**30.9**	**34.6**	**26.8**	**37.7**	**4.6**	**20**	**0.563**

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	**28.4**	**94.8**	**61.1**	**91.3**	**61.2**	**89.5**	**61.0**	**65.9**	**83.1**	**64.6**	**82.2**	**63.4**	**81.5**	**9.1**	**130**

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Extreme Max WB
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
61.3	**97.6**	**70.3**	**59.2**	**90.5**	**69.8**	**57.1**	**84.0**	**69.1**	**33.5**	**83.6**	**32.4**	**82.3**	**31.4**	**80.8**	**71.2**

Recommended for Dual-Fuel Heat Pumps (and code)
Recommended for All-Electric Heat Pump

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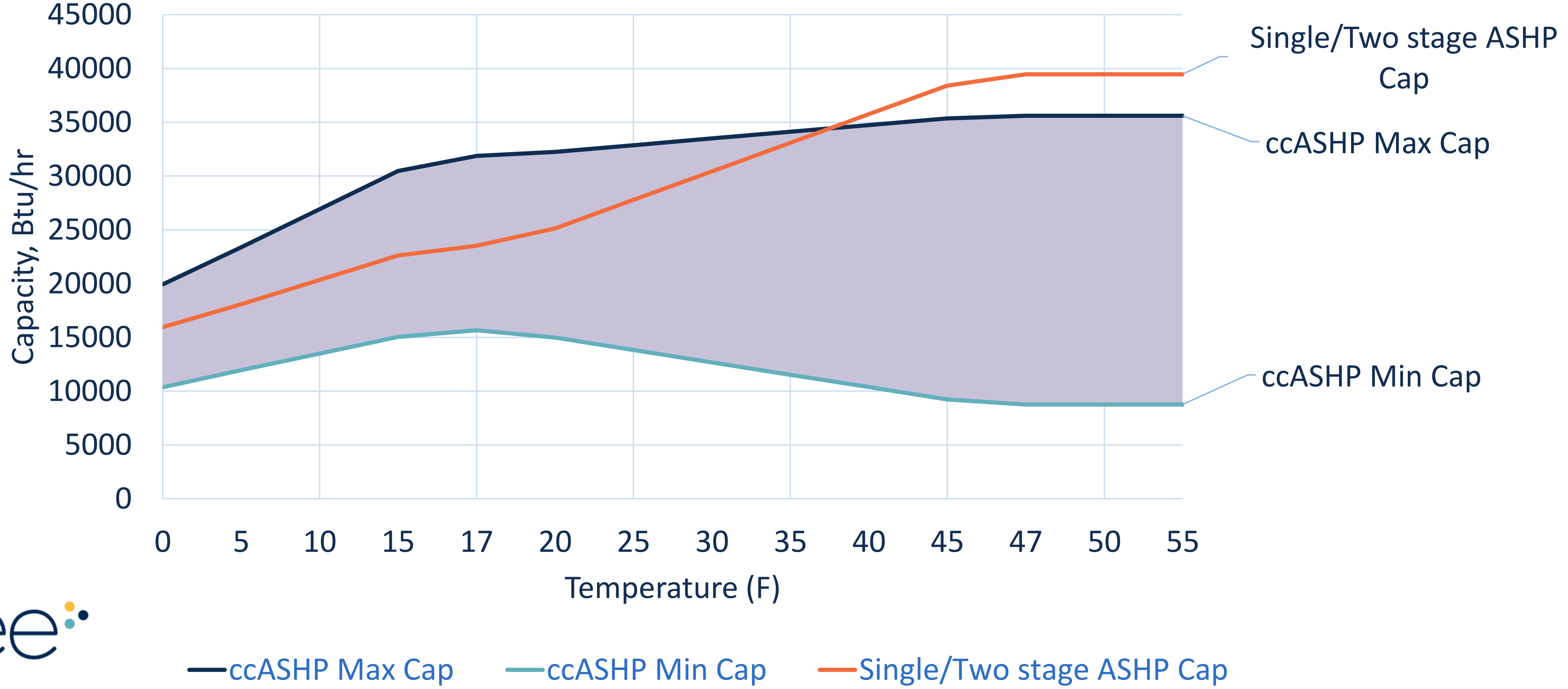
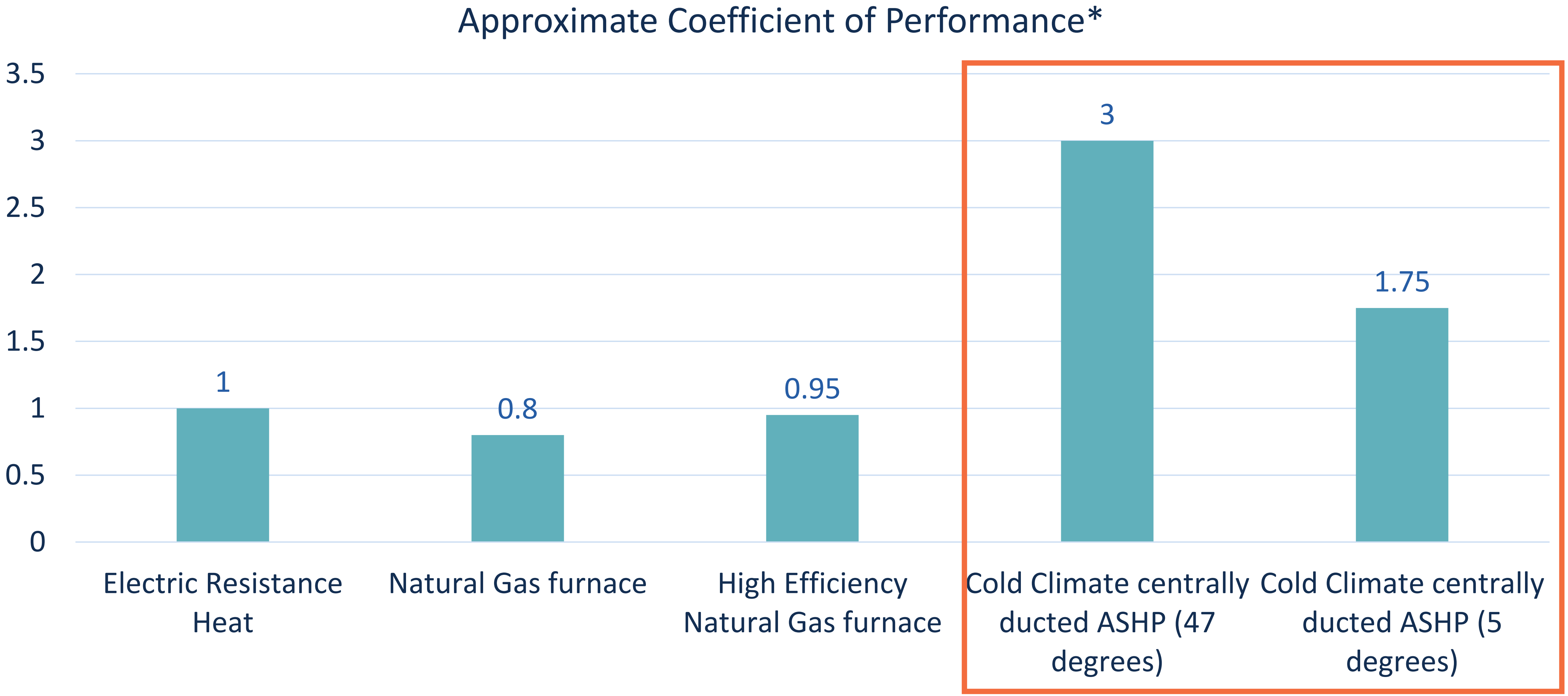
Cold climate systems modulate to load for increased comfort and savings while offering higher capacity at lower temperatures

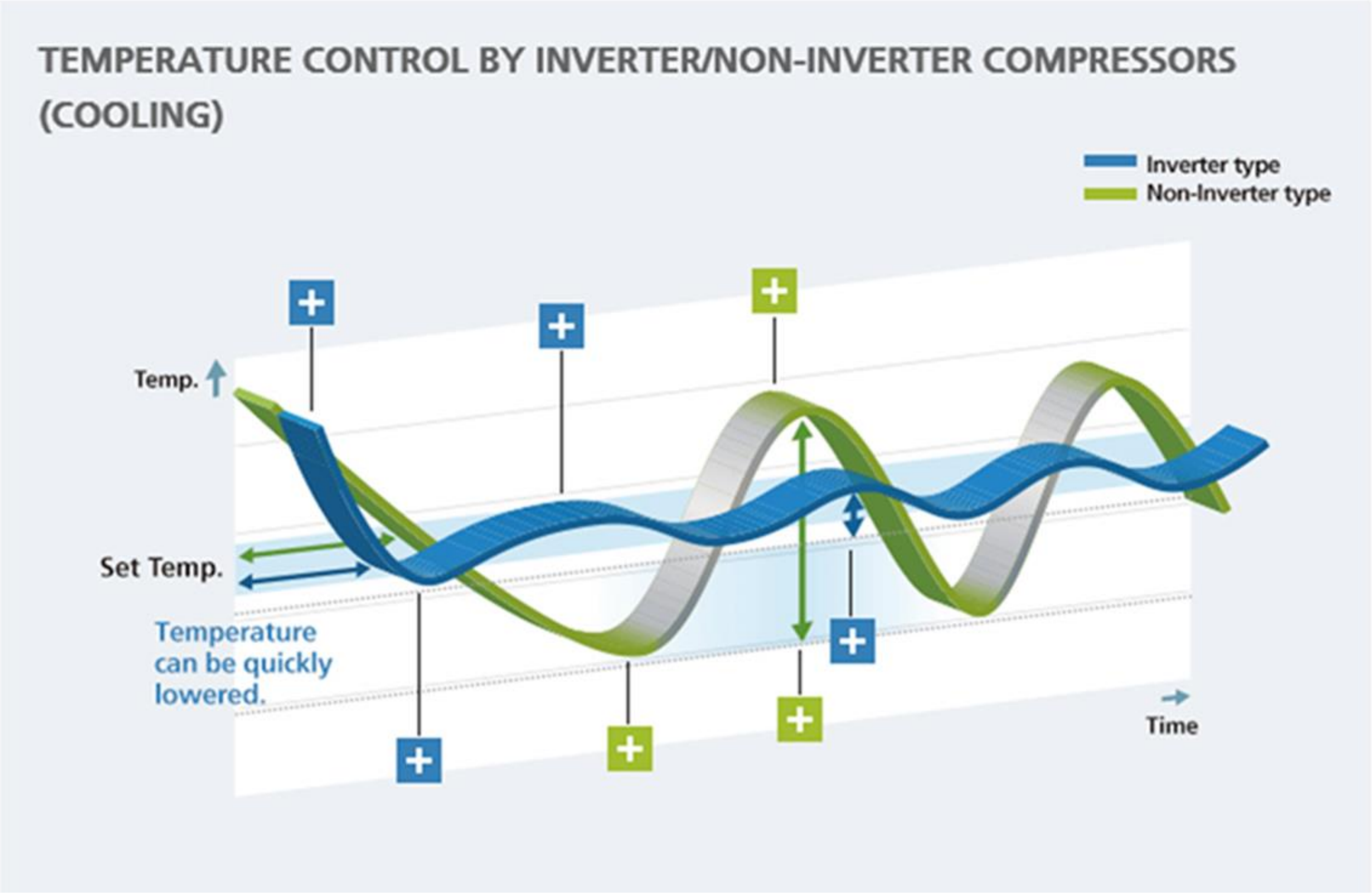


Level setting on COP by system type



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

NEW G



TEMPERATURE CONTROL BY INVERTER/NON-INVERTER COMPRESSORS (COOLING)
Inverter type
Non-Inverter type
Temp.
Set Temp.
Temperature can be quickly lowered.
Time

How do cold climate heat pumps work?

- Higher compressor speeds
- Variable refrigerant flows
- Rerouting excess hot refrigerant back through indoor coil
- In some cases, indoor air flow is adjusted
- Variable capacity heat pumps typically use between 0.85 to 9.5 kWh/hr
- At low compressor speed, moderate refrigerant flow, and moderate air handler flow, they may use 1.5 to 3 kW
- At higher compressor speed, more intense refrigerant flow, and adjusted air handler flow, they may use 4 to 8 kW.
  - ***Heat pump is typically 2 to 3 times more efficient in cool, but not frigid climates***

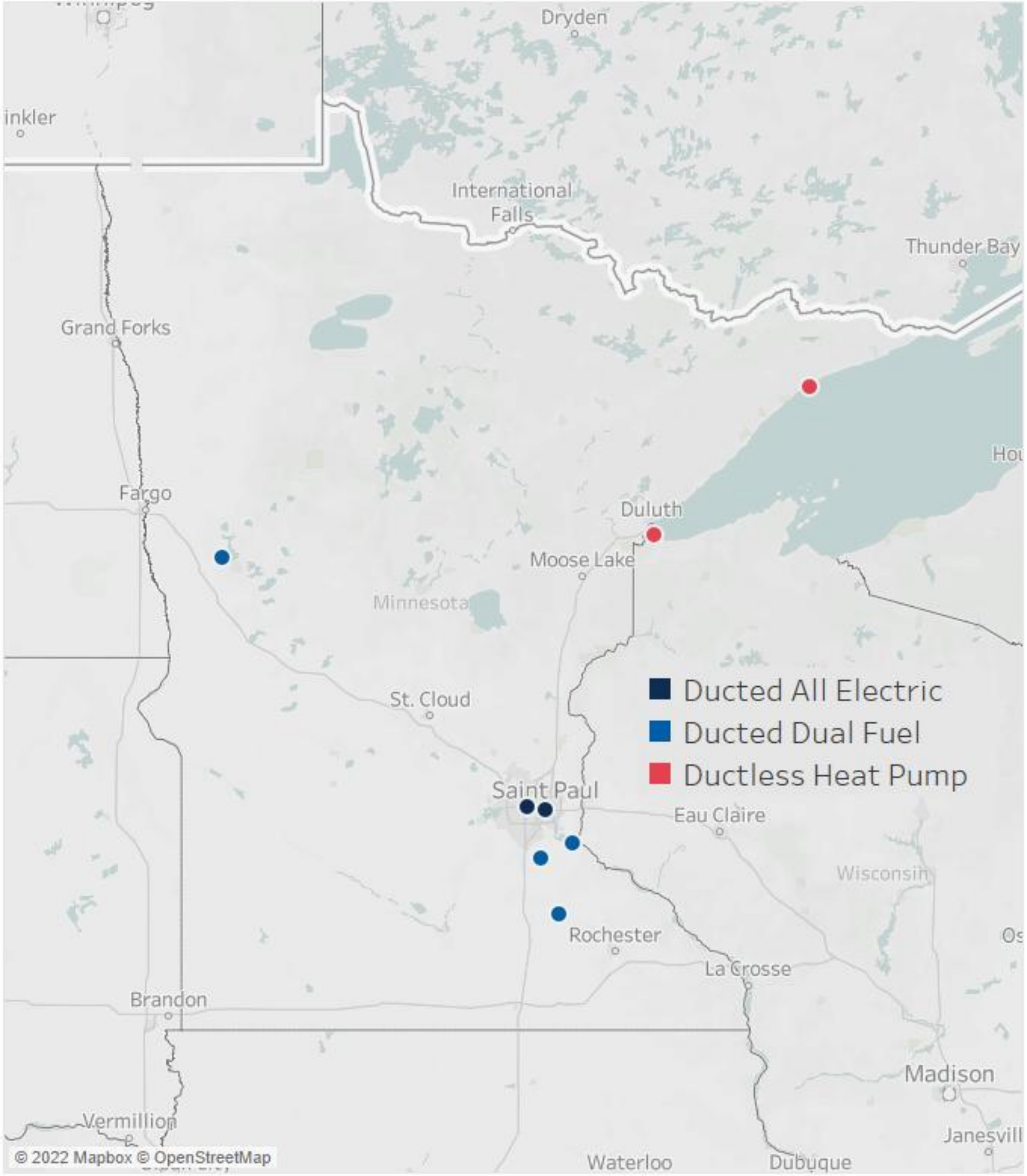
CEE Research Example

Field Study

- 8 ccASHP in a variety of MN residences
  - 6 ducted whole house system
  - 2 ductless mini-split systems
- Monitor installed field performance of ASHP & backup

Each site had detailed data collection

Installs in climate zones 6 & 7



Slipstream research example

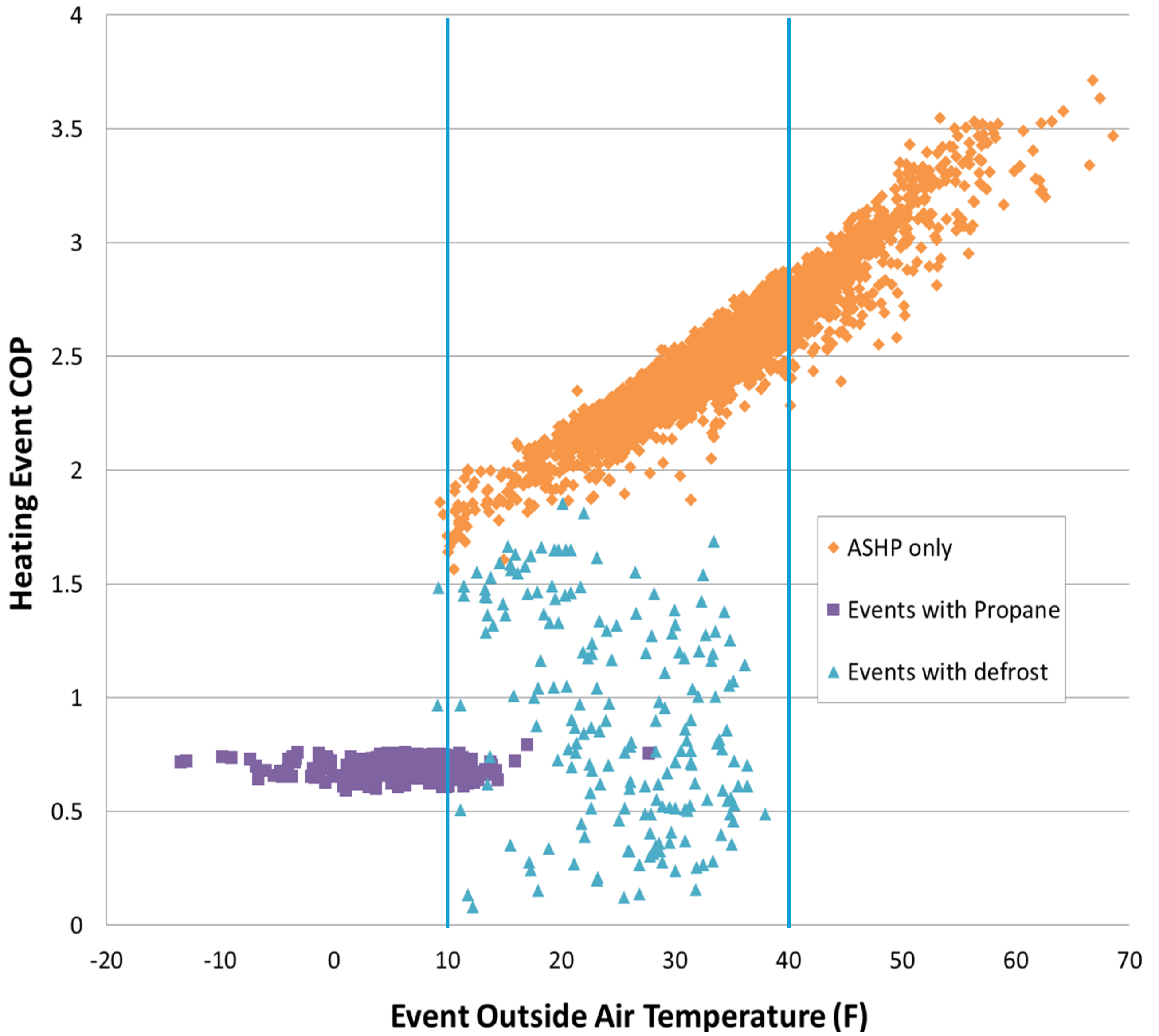
Field Study (2019)

- 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

HEATING CYCLE COP OF DUAL FUEL SYSTEM



CEE AND SLIPSTREAM'S FIELD RESEARCH RESULTS

- Significant savings for replacing propane and electric resistance

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

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

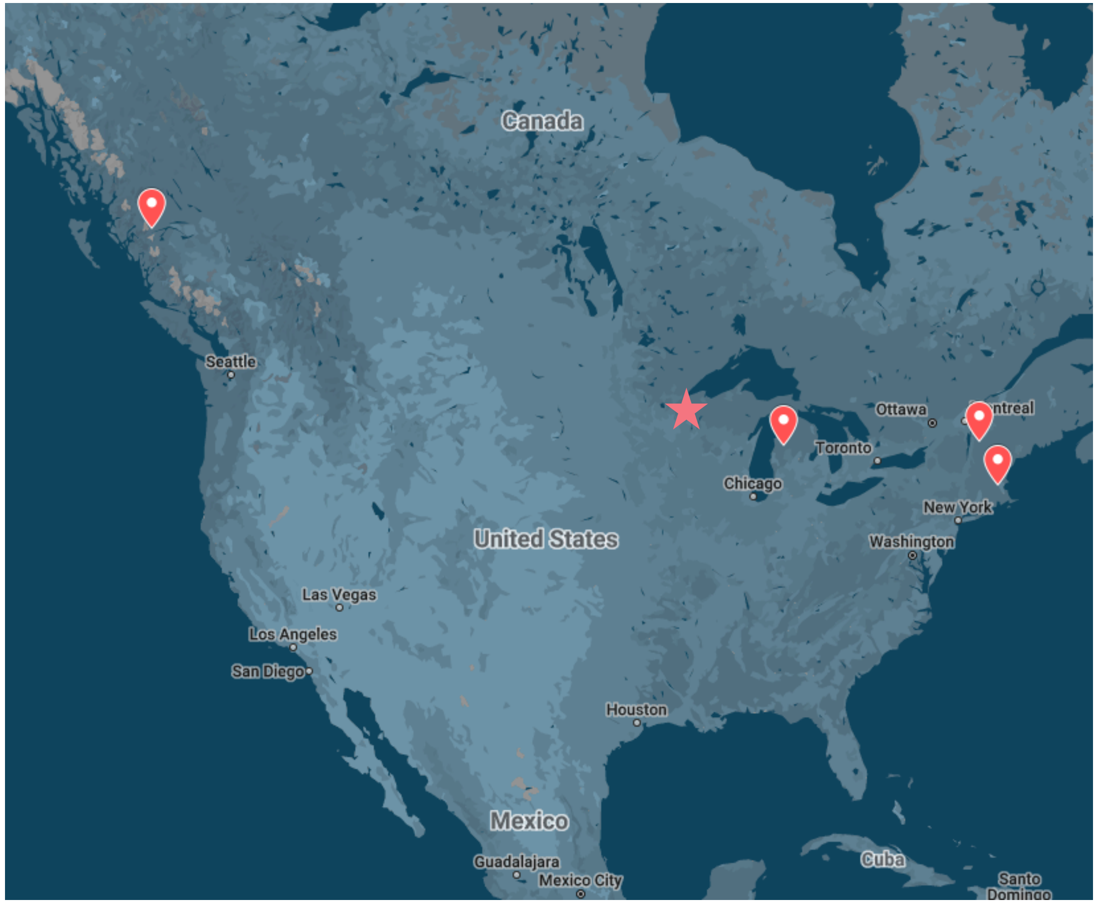
RESEARCHED CONFIRMED BY OTHERS

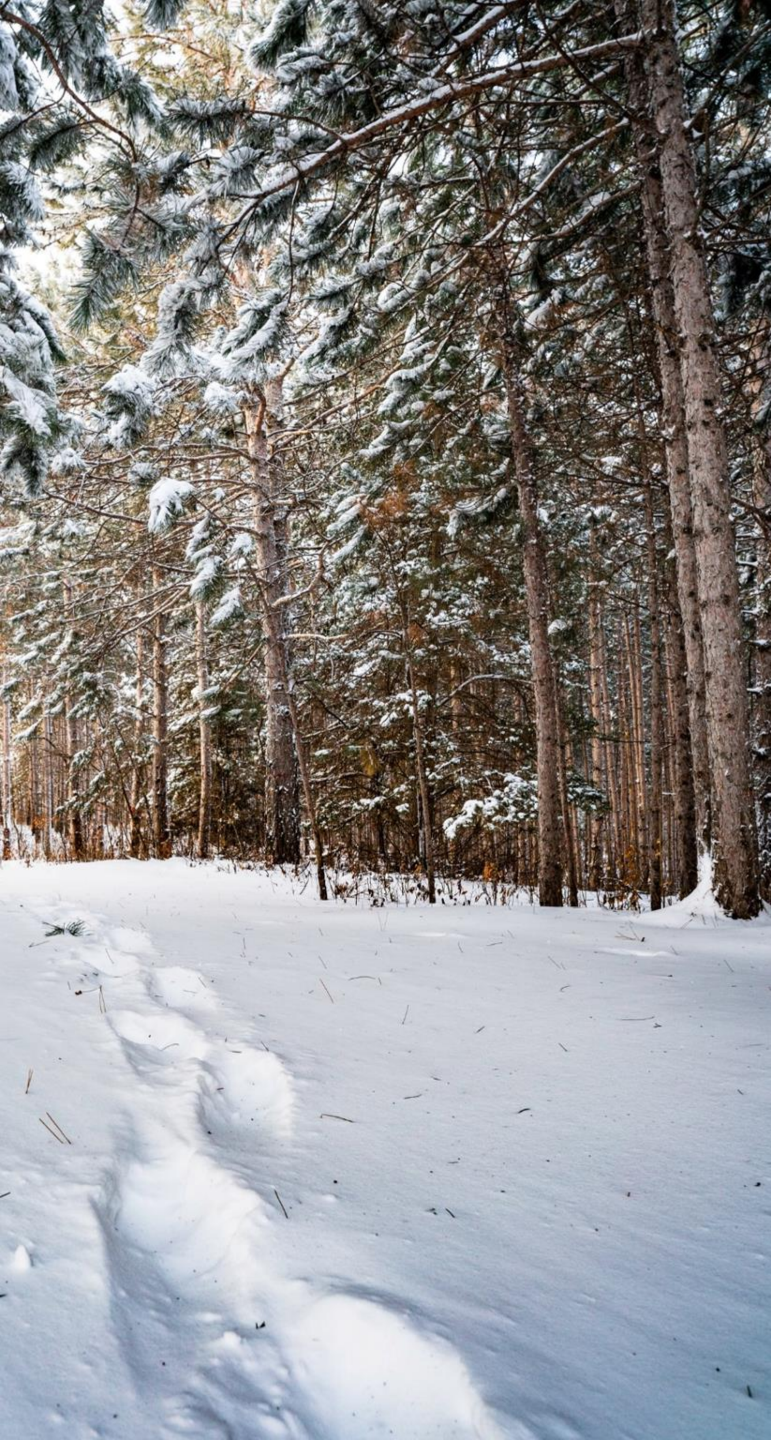
2019 Dual Fuel Air-Source Heat Pump Monitoring Report [Michigan] – *Slipstream*

British Columbia [Canada] Cold Climate Heat Pump Field Study – *RDH Building Science*

Air-Source Heat Pumps in Cold Climates [Vermont] – *Steven Winter Associates, Inc*

Cold Climate Air Source Heat Pump Building Electrification Study 2020-2021 – [Massachusetts] *Clean Energy Center*





REALLY…IN COLD CLIMATES?

- Variable capacity advancements have expanded cold climate performance
- Standardization of a cold climate performance specification
- Field research studies **observed systems delivering heat as cold as -25°F!**

Summary

Colorado is a cold climate!

Research shows that heat pumps work in cold climates

Customers see benefits through

- Heating and cooling in one
- Savings
- Rebates and incentives

Technology continues to progress!

Using the Heating Load Estimator

This **tool is designed for rough estimations, training, and gut checks** of heating loads for existing equipment or to truth check a Manual J or ASHRAE based heating load calculator. **This is NOT intended to replace Manual J or locally approved heat load calculators.**

For each temperature range and construction type, a range of Btuh/sq ft is provided. The simple approach is to use the bolded, central number. This is most commonly used when checking another tool as a guide. Homes with basements tend to have less heat loss in winter, but slightly more in late spring and early fall. To that point, a second set of estimated BTUH/sq ft has been provided for basement homes.

For evaluating an existing heating system capacity to determine if right, under, or over sized, it's most helpful to generate a range. If the equipment capacity in a heating climate is HIGHER than the range, it is likely oversized. If LOWER than the range, it is likely undersized.

If a blower door number is known, then using the appropriately aligned number may provide greater accuracy. A home where the CFM50 divided by the square footage of the home is 0.75 to 1.0, the home is of average tightness. Below 0.75 indicates a somewhat tight home. Over 1.0 is a somewhat leaky home. See next slide for a visual representation…

Find Winter Design Temperatures here (recommend using most current year data): ASHRAE Climatic Design Conditions or use the winter design temperatures assigned by local codes/programs.

CFM50/Square Foot assessment

Notes and Example

Building tightness is most useful when compared to the building size.

If you don't know the blower door number, use the center value for insulation level vs design temp.

If you do know the blower door number, refer to the table on the right of this slide.

Somewhat tight, average, somewhat leaky

CFM50\Sq Ft	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	*Sq Ft Home*
749	0.749	0.599	0.499	0.428	0.375	0.333	0.300	0.272	0.250	0.230	0.214	
1000	1.000	0.800	0.667	0.571	0.500	0.444	0.400	0.364	0.333	0.308	0.286	
1250	1.250	1.000	0.833	0.714	0.625	0.556	0.500	0.455	0.417	0.385	0.357	
1500	1.500	1.200	1.000	0.857	0.750	0.667	0.600	0.545	0.500	0.462	0.429	
1750	1.750	1.400	1.167	1.000	0.875	0.778	0.700	0.636	0.583	0.538	0.500	
2000	2.000	1.600	1.333	1.143	1.000	0.889	0.800	0.727	0.667	0.615	0.571	
2250	2.250	1.800	1.500	1.286	1.125	1.000	0.900	0.818	0.750	0.692	0.643	
2500	2.500	2.000	1.667	1.429	1.250	1.111	1.000	0.909	0.833	0.769	0.714	
2750	2.750	2.200	1.833	1.571	1.375	1.222	1.100	1.000	0.917	0.846	0.786	
3000	3.000	2.400	2.000	1.714	1.500	1.333	1.200	1.091	1.000	0.923	0.857	
3250	3.250	2.600	2.167	1.857	1.625	1.444	1.300	1.182	1.083	1.000	0.929	
3500	3.500	2.800	2.333	2.000	1.750	1.556	1.400	1.273	1.167	1.077	1.000	
CFM50												

Somewhat Tight
Average
Somewhat Leaky

Heating Load Estimator

Design Load ROUGH Estimator/Gut Checker Btuh/sq. ft.				
Climate Winter Design Temp in °F @99% (best for dual fuel HPs or when code requires) Climate Winter Design Temp in °F @99.6% (for all electric heat pumps, but follow code/permitting requirements)				
	Below – 10°F	**-10°F to 5°F**	**5°F to 20°F**	**Above 20°F**
No wall insulation (leaky, average, tight)	50, **47**, 44	44, **41**, 38	38, **35**, 32	32, **30**, 28
2x4 Const w/ Insul (leaky, average, tight)	27, **25**, 23	24, **22**, 20	21, **19**, 17	19, **17**, 15
2x6 Const w/ Insul (leaky, average, tight)	20, **18**, 16	17, **15**, 13	15, **13**, 11	13, **11**, 10
Newer const 2012 + (leaky, average, tight)	17, **16**, 15	15, **14**, 13	13, **12**, 11	11, **9**, 8

Original estimator created by the Northwest Energy Efficiency Alliance, edited for variable capacity heat pumps by Dan Wildenhaus

Heating Load Estimator – Basement Houses

Design Load ROUGH Estimator/Gut Checker Btuh/sq. ft.				
Climate Winter Design Temp in ºF @99% (best for dual fuel HPs or when code requires) Climate Winter Design Temp in ºF @99.6% (for all electric heat pumps, but follow code/permitting requirements)				
	Below – 10ºF	**-10ºF to 5ºF**	**5ºF to 20ºF**	**Above 20ºF**
No wall insulation (leaky, average, tight)	47, **44**, 41	41, **38**, 35	35, **32**, 29	30, **28**, 26
2x4 Const w/ Insul (leaky, average, tight)	25, **23**, 21	22, **20**, 18	19, **17**, 15	17, **15**, 13
2x6 Const w/ Insul (leaky, average, tight)	18, **16**, 14	15, **13**, 11	13, **11**, 9	11, **10**, 9
Newer const 2012 + (leaky, average, tight)	16, **15**, 14	14, **13**, 12	12, **11**, 10	9, **8**, 7

Original estimator created by the Northwest Energy Efficiency Alliance, edited for variable capacity heat pumps by Dan Wildenhaus

Example

- Home is 2x4 construction with insulation. No basement.
- **Home tightness is not known.**
- Home is 2,000 square feet
- Home is expecting to have a dual-fuel/hybrid heat pump.
- Home is in a location where the winter design temperature at 99% is -2°F.
- Existing system is a 60k BTU furnace

Design Load ROUGH Estimator/Gut Checker Btuh/sq. ft.				
Climate Dual Fuel HP Winter Design Temp in °F @99% Climate All Electric HP Winter Design Temp in °F @99.6%				
	Below – 10°F	**-10°F to 5°F**	**5°F to 20°F**	**Above 20°F**
No wall insulation (leaky, average, tight)	50, **47**, 44	38, **41**, 44	32, **35**, 38	32, **30**, 28
2x4 Const w/ Insul (leaky, average, tight)	27, **25**, 23	24, **22**, 20	21, **19**, 17	19, **17**, 15
2x6 Const w/ Insul (leaky, average, tight)	20, **18**, 16	17, **15**, 13	15, **13**, 11	13, **11**, 10
Newer const 2012 + (leaky, average, tight)	17, **16**, 15	15, **14**, 13	13, **12**, 11	11, **9**, 8

A projected range for the heating load is likely to be between:

24 x 2,000 = **48,000**

20 x 2,000 = **40,000**

System is likely oversized!

Example 2

- Home is 2x4 construction with insulation. No basement
- **Home tightness is known:**
  - **Blower door test is 1750 CFM50**
- Home is 2,000 square feet
- Home is expecting to have a dual-fuel/hybrid heat pump.
- Home is in a location where the winter design temperature at 99% is -2°F.
- Existing system is a 48k Btu furnace

Design Load ROUGH Estimator/Gut Checker Btuh/sq. ft.				
Climate Winter Design Temp in °F @99% (best for dual fuel HPs or when code requires) Climate Winter Design Temp in °F @99.6% (for all electric heat pumps, but follow code/permitting requirements)				
	Below – 10°F	**-10°F to 5°F**	**5°F to 20°F**	**Above 20°F**
No wall insulation (leaky, average, tight)	50, **47**, 44	38, **41**, 44	32, **35**, 38	32, **30**, 28
2x4 Const w/ Insul (leaky, average, tight)	27, **25**, 23	24, **22**, 20	21, **19**, 17	19, **17**, 15
2x6 Const w/ Insul (leaky, average, tight)	20, **18**, 16	17, **15**, 13	15, **13**, 11	13, **11**, 10
Newer const 2012 + (leaky, average, tight)	17, **16**, 15	15, **14**, 13	13, **12**, 11	11, **9**, 8

Using the blower door number to get a more specific design load estimate

1750 / 2000 = 0.875 = Average

Heating load estimate = **44,000 Btuh**

System is within the right nominal size

Center for Energy and Environment

Designing for the Heating Load

Focus on Tier 2 rebate systems

I hope this looks familiar to you!

Efficiency Works™

Estes Park | Fort Collins | Longmont | Loveland

Appendix A: Installation standards

Heat pumps

Existing conditions

- Allowed in gas or electrically heated homes

Installation standards

- System must be right-sized using an ACCA approved Manual J (Version 7 minimum) block load calculations.
- Determine if existing forced air system duct size is large enough for heat pump.
- **Unmatched air source heat pump split system**
  (Does not qualify for Colorado Heat Pump Tax Credits)
  16.0 SEER & 9.0 HSPF
  or
  15.2 SEER2 & 7.8 HSPF2
  Shall not exceed .8 IWC TESP
  Change over temperature < 35 F
  Size for cooling load

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Tier 1 Requirements

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Appendix A: Installation standards

Heat pumps

Existing conditions

- Allowed in gas or electrically heated homes

Installation standards

- System must be right-sized using an ACCA approved Manual J (Version 7 minimum) block load calculations.
- Determine if existing forced air system duct size is large enough for heat pump.
- **Tier 1: Non-Cold Climate Heat Pump**
  16 SEER and 9 HSPF
  or
  15.2 SEER2 and 7.8 HSPF2
  Heat pump condenser, evaporator, and furnace must be AHRI matched.
  Shall not exceed .8 IWC TESP
  Change over temperature < 35 F
  Size for cooling load

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Tier 2 Requirements

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Appendix A: Installation standards

Heat pumps

Existing conditions

- Allowed in gas or electrically heated homes

Installation standards

- System must be right-sized using an ACCA approved Manual J (Version 7 minimum) block load calculations.
- Determine if existing forced air system duct size is large enough for heat pump.
- **Tier 2: Cold-Climate Heat Pump**
  16 SEER and 9.5 HSPF
  or
  15.2 SEER2 and 8.1 HSPF2
  Heat pump condenser, evaporator, and furnace (if applicable), must be AHRI matched.
  Shall not exceed .8 IWC TESP
  Cold climate HP certified by NEEP, ENERGY STAR®, CEE, or AHRI
  Change over temperature of < 5F
  Size for 100% of the heating load

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Ductless Requirements

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Appendix A: Installation standards

Heat pumps

Existing conditions

- Allowed in gas or electrically heated homes

Installation standards

- System must be right-sized using an ACCA approved Manual J (Version 7 minimum) block load calculations.
- 21 SEER & 9.5 HSPF

  or
- 21 SEER2 & 9.1 HSPF2
- Cold climate HP, certified by NEEP, ENERGY STAR, CEE, or AHRI
- Can be designed for the heating load

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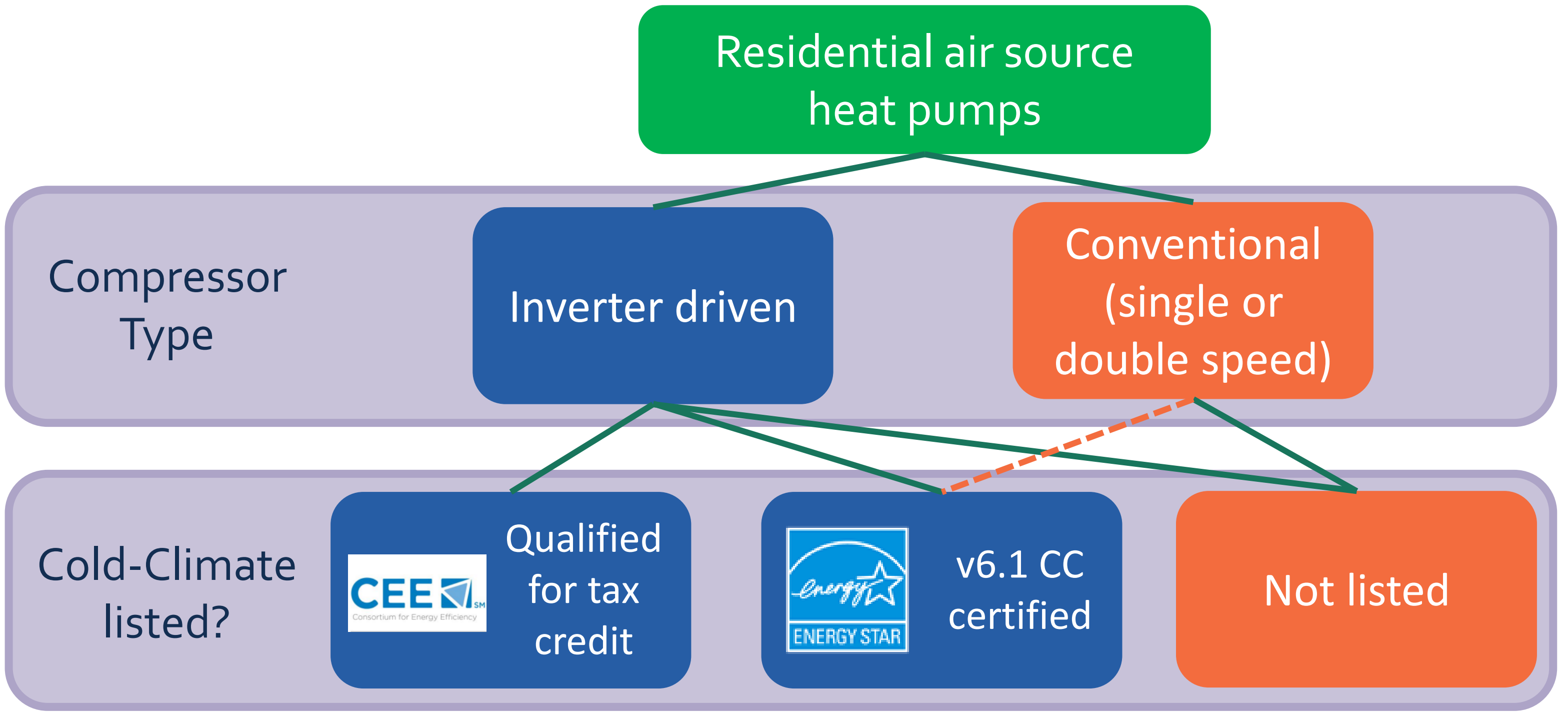
Center for Energy and Environment

Cold Climate Certifications and Specifications

As of September 20th, 2024

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!

WHAT IS CCASHP TECHNOLOGY?

Typical **Efficiency Requirements**

- Greater than ≥18 SEER2
- Greater than ≥11.7 EER2
- Greater than ≥8.1 HSPF2

Performance

- Max capacity at 5º F at least 70% of rated capacity at 47° F
- COP at 5ºF of 1.75 or higher

Northeast Energy Efficiency Partnership (NEEP) cold climate product list

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Additional incentives

Measures	Efficiency Works rebate	Xcel rebate	Colorado Tax Credit	Federal Tax Credit (up to 30% of cost)	Federal Home Electrification and Appliance Rebates (HEAR)**	Total incentives
Ductless minisplit (cold climate)	$500/ton*	$750/ton*	$499	$2,000	Up to $4,000	Up to $8,999
Standard air source heat pump	$1,500*	$300/cooling ton* @ 95° F	NA	$2,000	Up to $1,500	Up to $5,600
Cold climate air source heat pump	$2,000*	$750/heating ton* @ 5° F	$499	$2,000	Up to $4,000	Up to $9,999
Heat pump water heater	$800	$800	$167	$2,000	$875	Up to $4,642
Ground source heat pump	$3,000	NA	$1,000	$2,000	Up to $4,000	Up to $10,000

*The provided values are based on a 2-ton system. All values are for 81-150% AMI (Area Median Income).

**The Federal Home Electrification and Appliance Rebates (HEAR) funds are not available currently. See the table below for more information.

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Specifications

Measures	Efficiency Works Specs	Xcel Specs	Colorado Tax Credit	Federal Tax Credit CEE1	Federal Home Electrification and Appliance Rebates (HEAR)**
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, 9.5 HSPF2, **9.0 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR Version To Be Finalized Soon
Standard air source heat pump	15.2 SEER2, 7.8 HSPF2 Switchover below 35ºF	15.2 SEER2, 7.8 HSPF2, **11.7 EER2**	NA	NA	ENERGY STAR Version To Be Finalized Soon
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	15.2 SEER2, 8.1 HSPF2 **10 EER2** 1.75 COP @5 70% cap maintenance	ENERGY STAR Version To Be Finalized Soon

Center for Energy and Environment

Specification Updates

Future Specifications 2025

Measures	Efficiency Works Specs	Xcel Specs	Colorado Tax Credit	Federal Tax Credit CEE1 2026	Federal Home Electrification and Appliance Rebates (HEAR)**
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!	ENERGY STAR Version To Be Finalized Soon
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** **45% cap maintenance**	ENERGY STAR Version To Be Finalized Soon
Cold climate air source heat pump (for whole house 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** **60% cap maintenance**	ENERGY STAR Version To Be Finalized Soon

Future Specifications 2026

Measures	Efficiency Works Specs	Xcel Specs	Colorado Tax Credit	Federal Tax Credit CEE1 2025	Federal Home Electrification and Appliance Rebates (HEAR)**
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!	ENERGY STAR Version To Be Finalized Soon
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**	ENERGY STAR Version To Be Finalized Soon
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**	ENERGY STAR Version To Be Finalized Soon

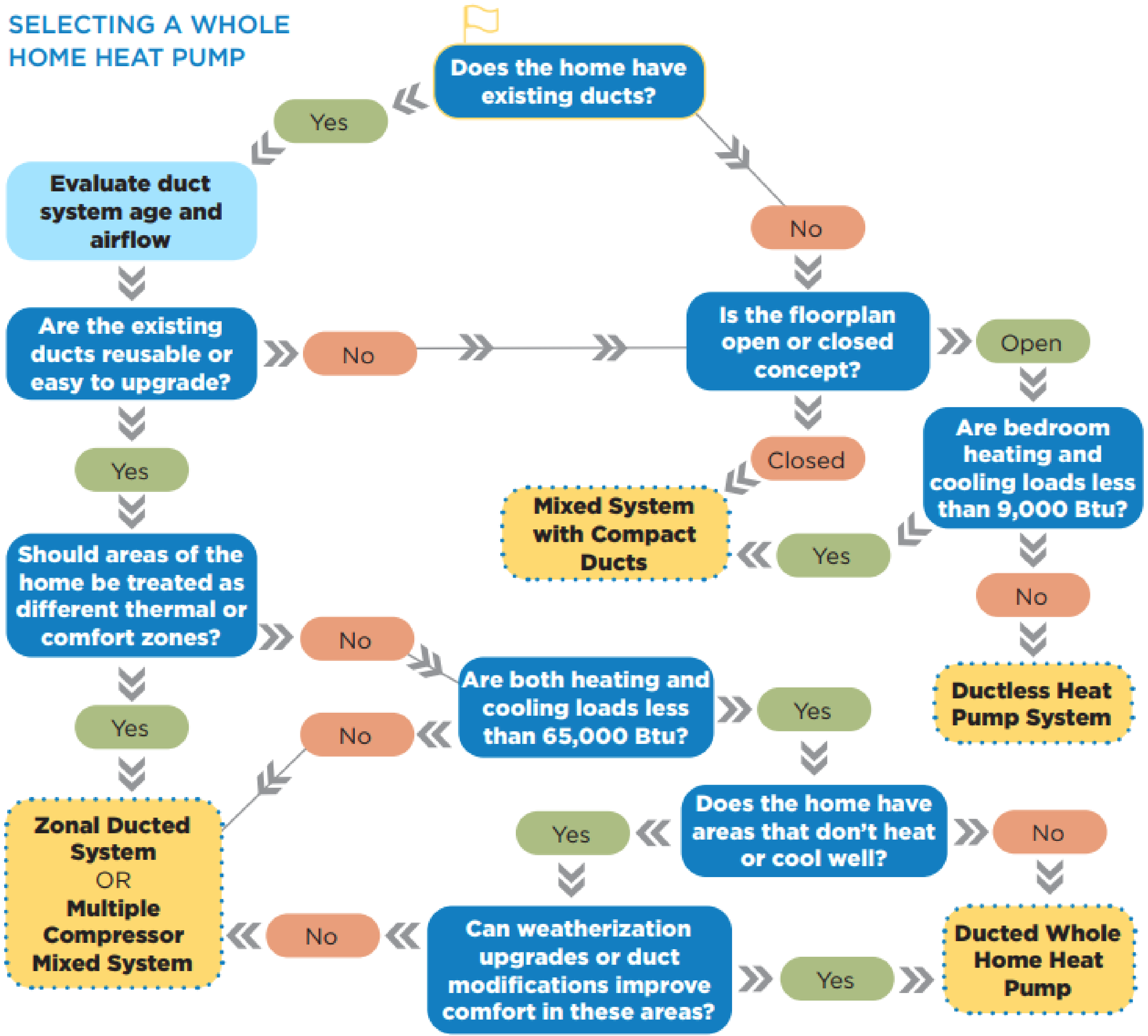
Center for Energy and Environment

Heat Pump Sizing

Specific to Front Range climate

Consortium for Energy Efficiency

Decision Matrix and System Design Guide



ASHP_Decision_Matrix_and_System_Design_Guide

CEE1 Decision Tree Tool

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 th[illegible] latent loa[illegible] are met
- Total equipment capacity is betwee[illegible]: - 9[illegible] and 115% of total cooling requirements (for air conditioners and heat pumps) *or* - [illegible]5% and 1[illegible]5% of t[illegible]al cooling requirements (for heat pumps in heating dominated climates).
- It allows stepping up to the next large[illegible]ominal [illegible]ce of equipment, per the desired product line, that is available to satisfy both the latent and sensible requirements.

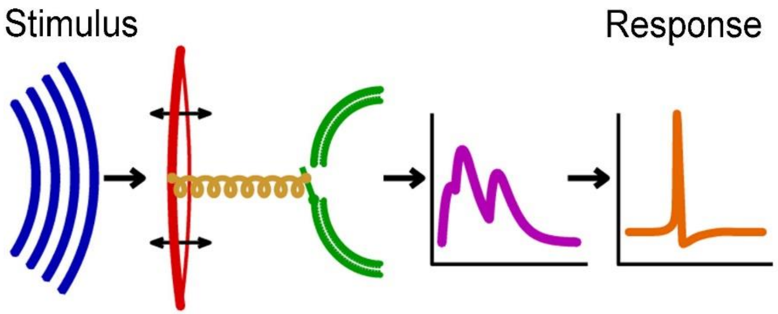
Updated Manual S sizing guidance

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

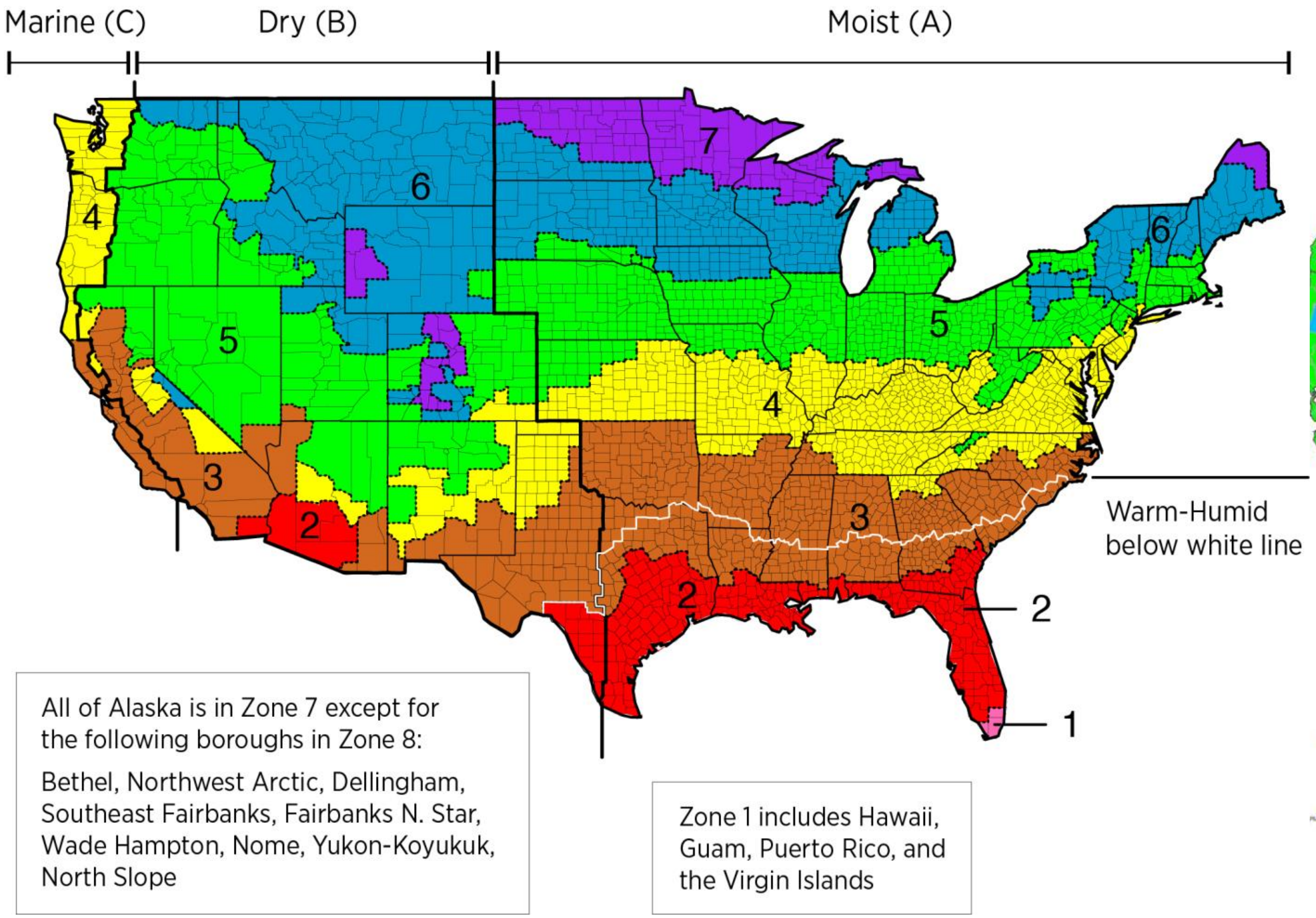
New Goal

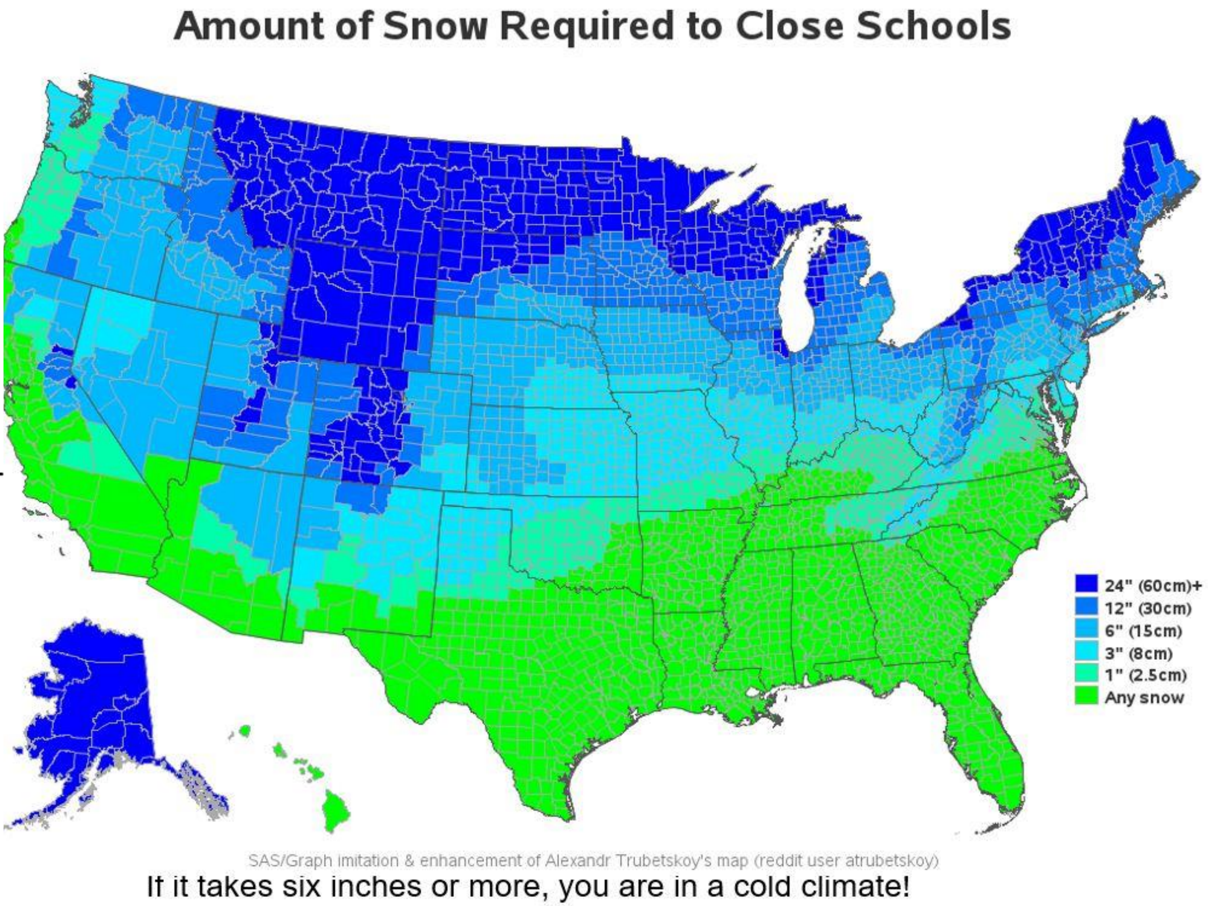
- Somewhat simplified guidance of each of the following:
  - Sizing for heating and cooling loads
  - Sizing for humidity and comfort
  - Considering house, homeowner, ducts, and control strategies
  - **Considering additional humidity control**
  - **Based on climate zone and goals**

Does this sound good to you?

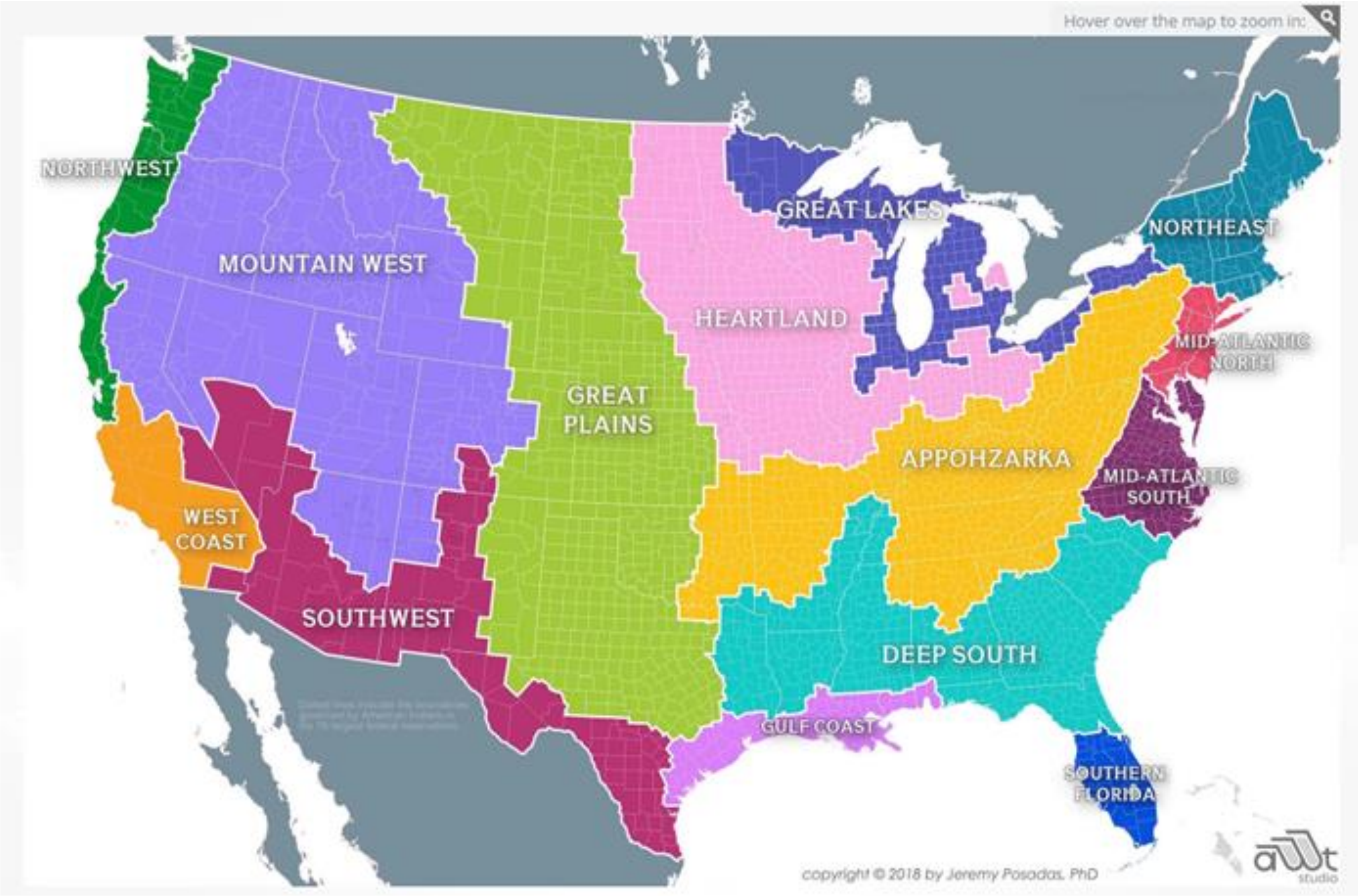


Climate zones reimagined

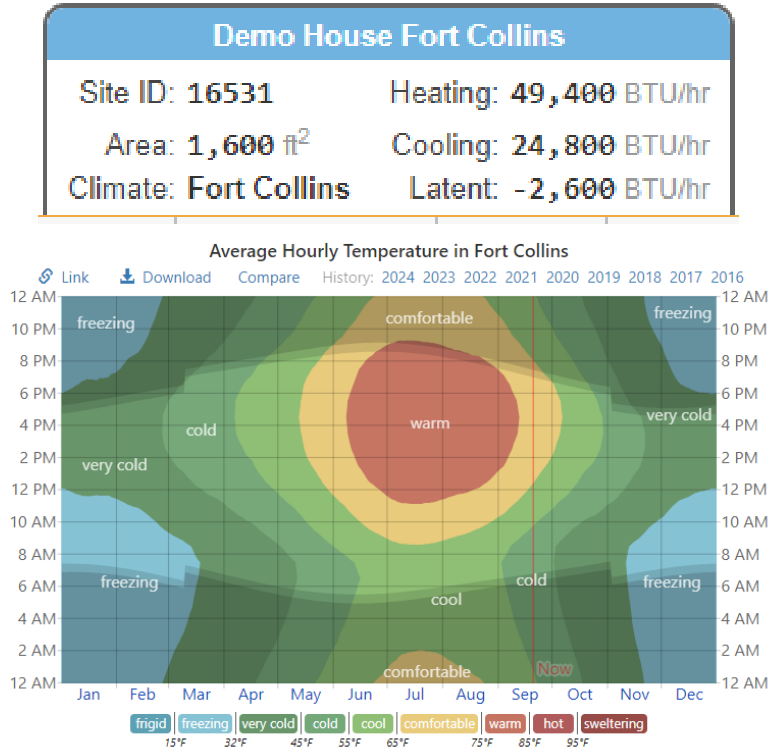


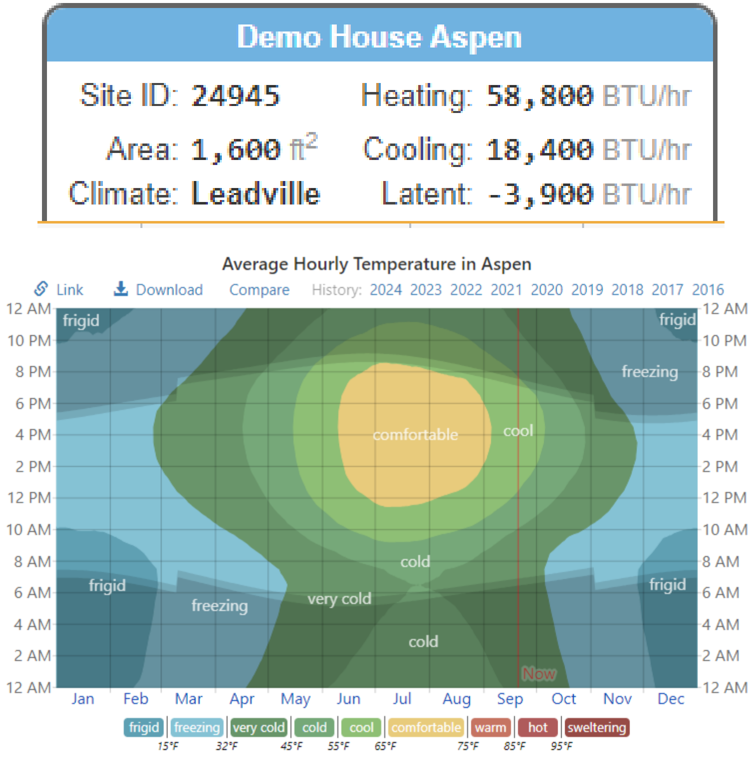


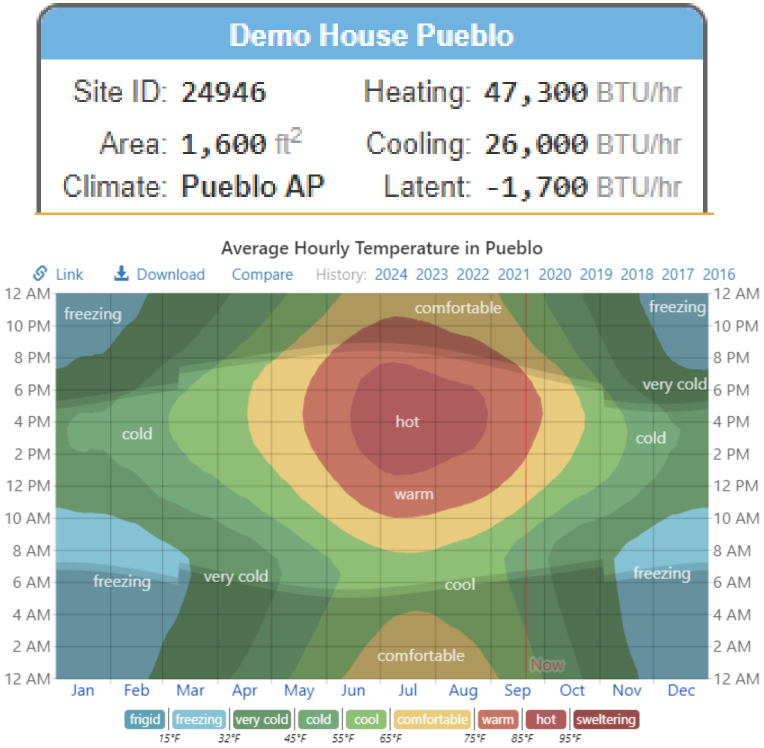
Climate zones reimagined



Same house – same heat pump – 3 cities







Heating load/cooling load = 1.99

Heating load/cooling **load = 3.20**

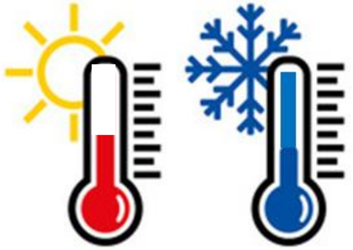
Heating load/cooling load = 1.82

Sensible Heat Ratio Over 1.0

Sensible Heat Ratio Way over 1.0

Sensible Heat Ratio Over 1.0

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 – Tier 1 rebate (dual fuel scenario)

1. **Right size**
   1. Size for cooling
   2. Let the Heat Pump work for 6 to 10 months of the year – 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. **<u>Great low-load capacity at 5ºF, 17ºF, and 47ºF</u>**
   2. **Great turn down ratio at 47ºF**
   3. **Good turn down ratio at 5ºF, 17ºF, 82ºF and 95ºF**
3. Consider pre-conditioning any intentional ventilation air
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**

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

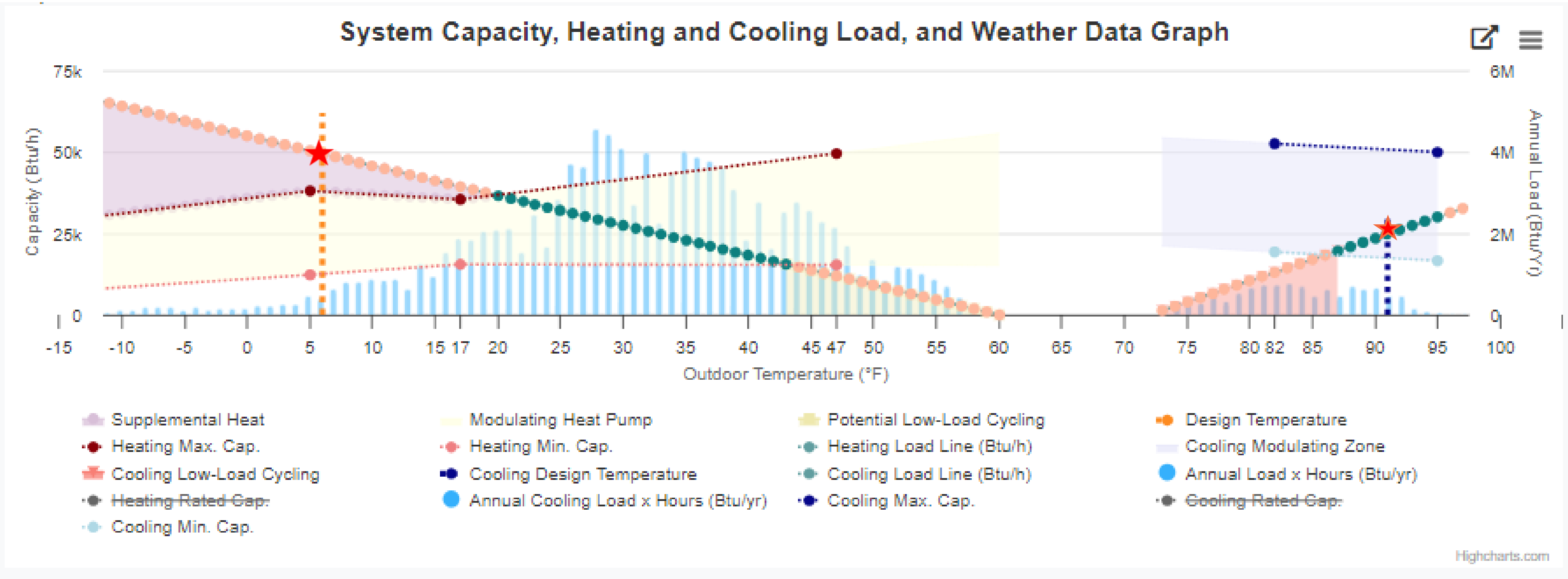
Attic %	20
Unconditioned Basement or Crawl Space %	0
Conditioned Area %	80

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			

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

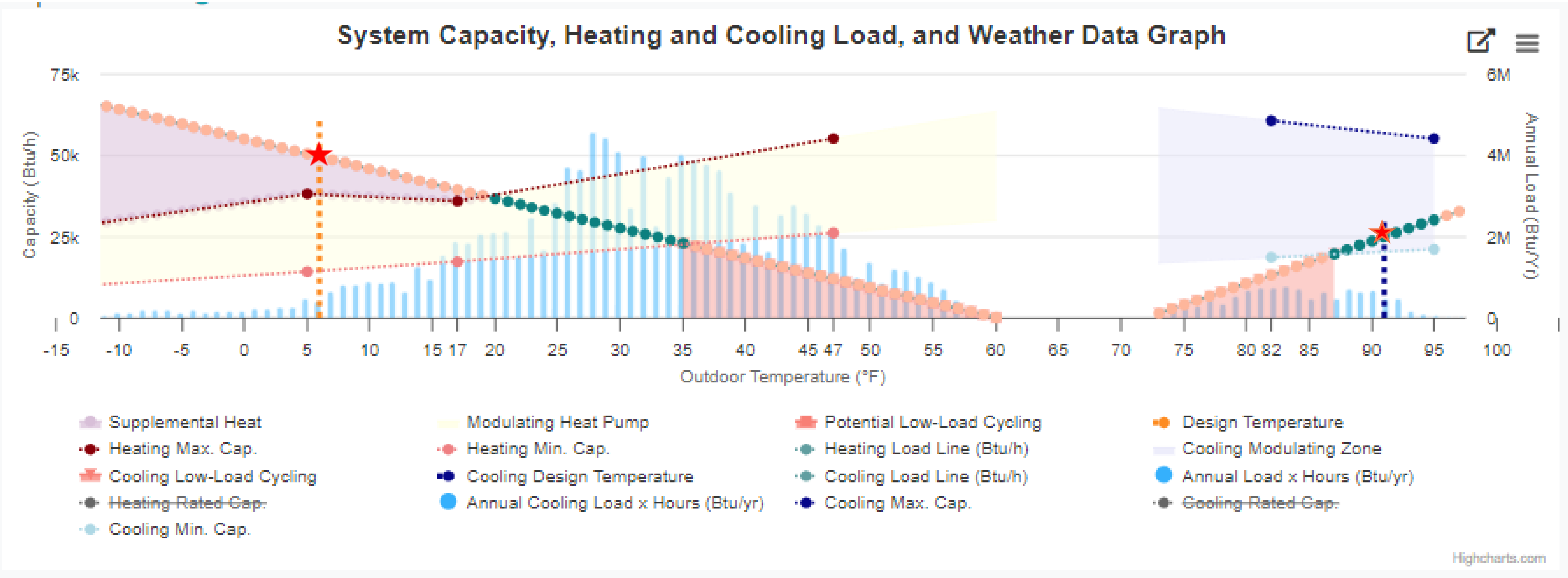
Minimum Capacity Threshold (°F)	87
Maximum Capacity at Design Temp (Btu/h)	50,700
Percent Design Load Served	204.4%
Annual Cooling Load (MMBtu)	11.0

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

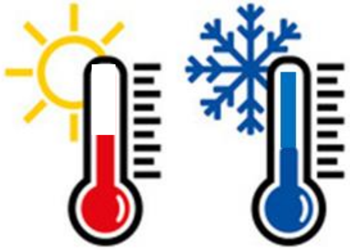
Minimum Capacity Threshold (°F)	87
Maximum Capacity at Design Temp (Btu/h)	56,692
Percent Design Load Served	228.6%
Annual Cooling Load (MMBtu)	11.0

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 – Tier 2 rebate – ccHP doing ~100% heating load

1. All-Electric heat pump approach
    1. Size for heating
    2. Let the Heat Pump do 95 to 100% of the heating load – cold climate variable capacity heat pump necessary
    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**
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 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**

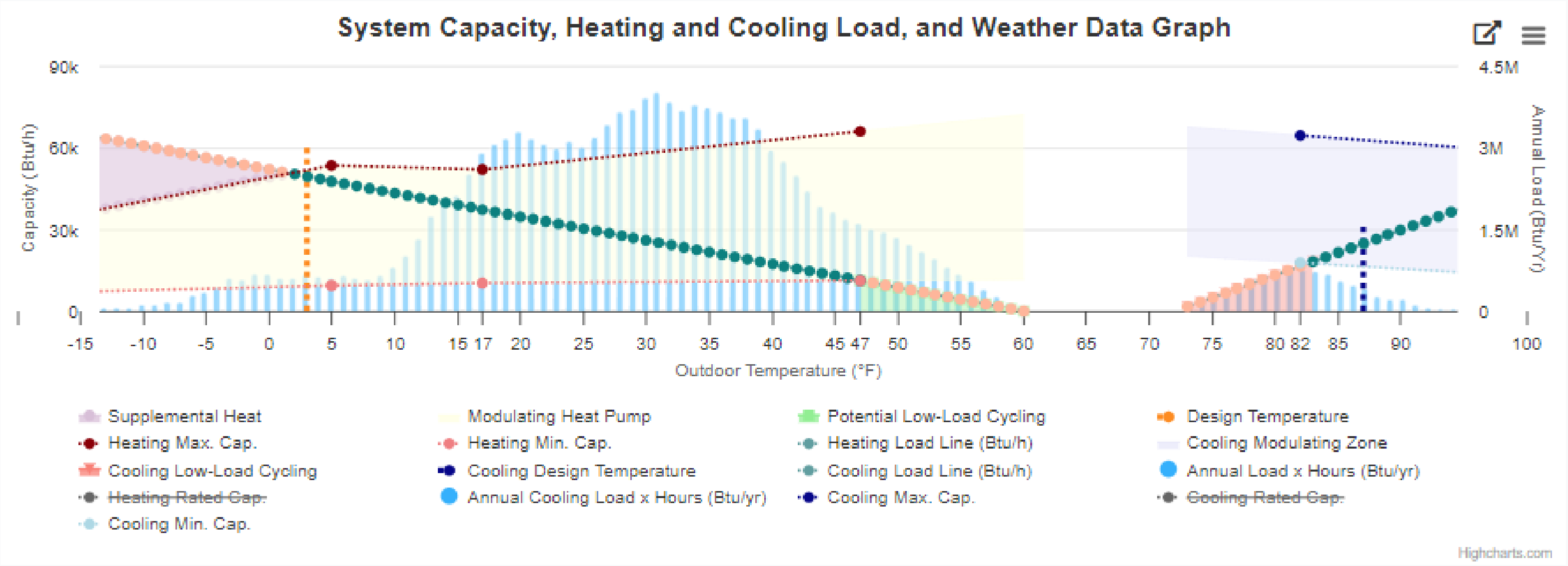
Maximum Heating Capacity (Btu/h) @5°F: **53,500**

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

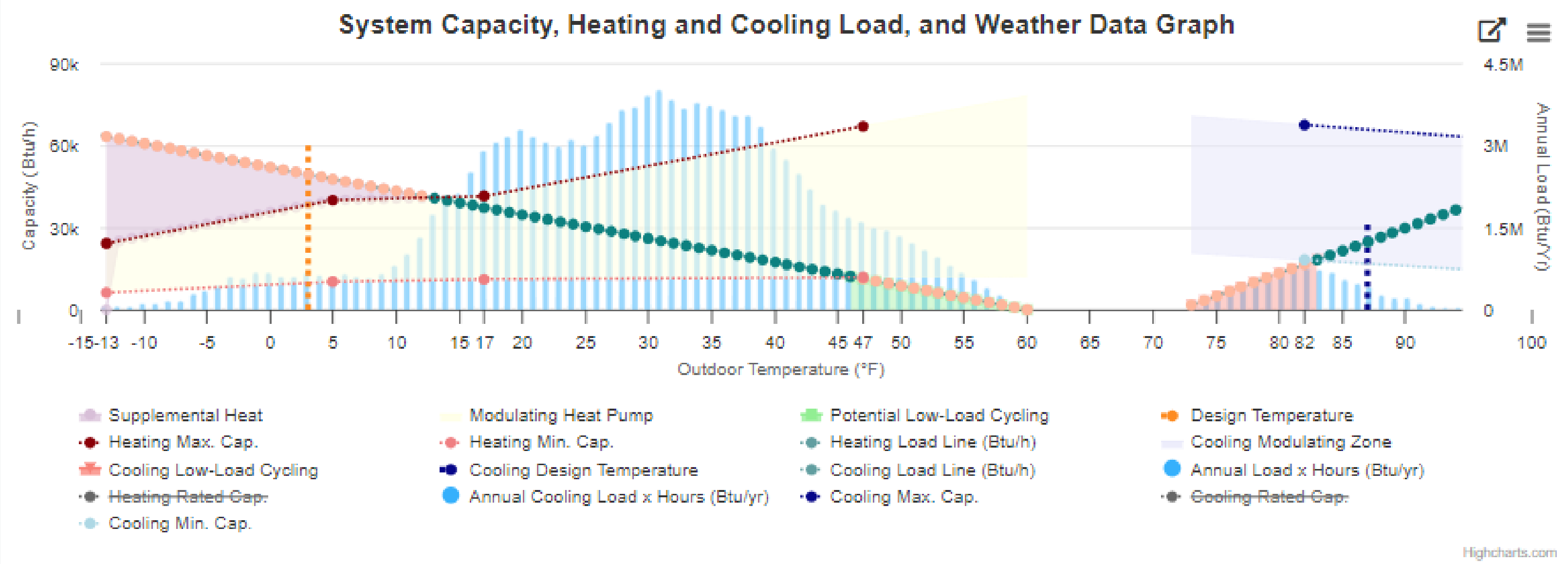
View Oversizing Effects

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%



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

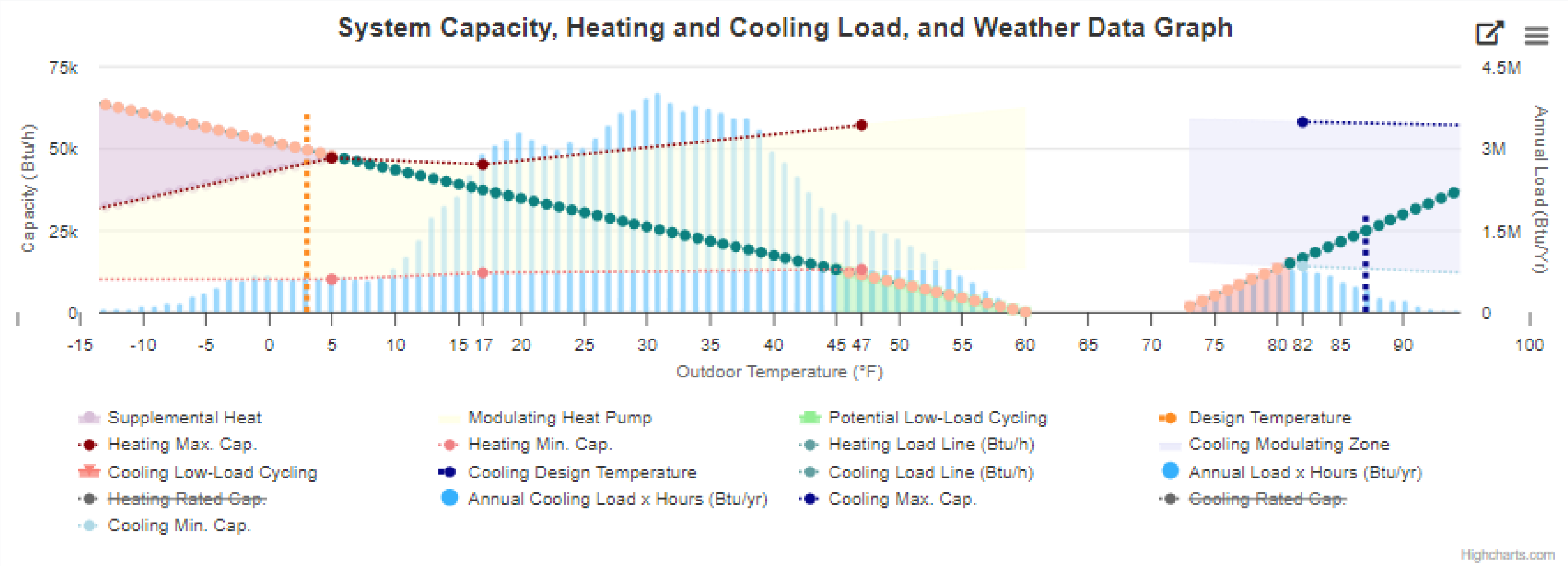
Minimum Capacity Threshold (°F)	83
Maximum Capacity at Design Temp (Btu/h)	65,769
Percent Design Load Served	265.2%
Annual Cooling Load (MMBtu)	8.8

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%

cee

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%

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

Low-e capable vs SHGC adjustable

Low-e glazing benefits

- Low-e coatings can significantly impact SHGC; this is especially true of solar control low-E coatings, which actively reflect the sun's short-wave infrared radiation and mitigate heat transfer through the window.

SHGC adjustable benefits

- The SHGC metric determines how much solar heat enters a home via a window. The lower the number, the less heat enters. SHGC numbers range between 0 and 1 and windows are generally between 0.25 and 0.8.

Mechanisms for lower SHGC in windows

- Window films and tints
  - A cost-effective option that can reduce heat gain without blocking views or natural light. Window film can also protect against glare and ultraviolet exposure.
- Low-emissivity (Low-E) coatings
  - These coatings can significantly reduce SHGC by reflecting solar radiation.
- Additional glazings (triple pane most commonly)
  - These windows have an additional layer of glass, making them ~30 to 60% more energy efficient than double-glazed windows. However, they typically cost more to install.

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 ft²	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.
- Your selected equipment should have **a sensible heat fraction of 0.89 (89%) or lower** if you want to dehumidify during typical run times. In Colorado, you’ll likely not need much dehumidification! But it’s still good to track this as it will feed into sizing and elevation adjustments.

Considerations for Front Range

- Fort Collins is at a high elevation – 5,003 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)

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)

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

32,872btu X 0.86 = 28,270

32,872 X 0.92 = 30,242

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

cee

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**

Adjustment: Add ½ of the latent load back

26,008 btu
+ 2,117 btu
28,125 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.**
- 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	N/A	N/A
Efficiency Guide	COP at Min to Rated capacity at 5°F, 17°F, 47°F, 82°F	COP at Min to Rated capacity at 17°F, 47°F, 82°F	COP at Min to Rated capacity at 5°F, 17°F, 47°F, 82°F	COP at Min to Rated capacity at 47°F, 82°F, 95°F
Weatherization recommended	Yes	Possibly	Possibly	Yes
Low-load Short Cycling (LLSC)	Watch for heating and cooling LLSC	Watch for heating and cooling LLSC	Watch for heating and cooling LLSC	Watch for heating and cooling LLSC
Ventilation air	HRV or ERV	ERV and/or Dehumidifier	ERV or Humidifier	HRV or ERV & Humidifier
Turndown ratio @ 47°F and 82°F	2+	2.5+	3+	2.25+
Dry Mode	Maybe	Maybe	No	No

Center for Energy and Environment

Sizing and Ducts

Myth =

The ductwork can’t handle a heat pump

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 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.

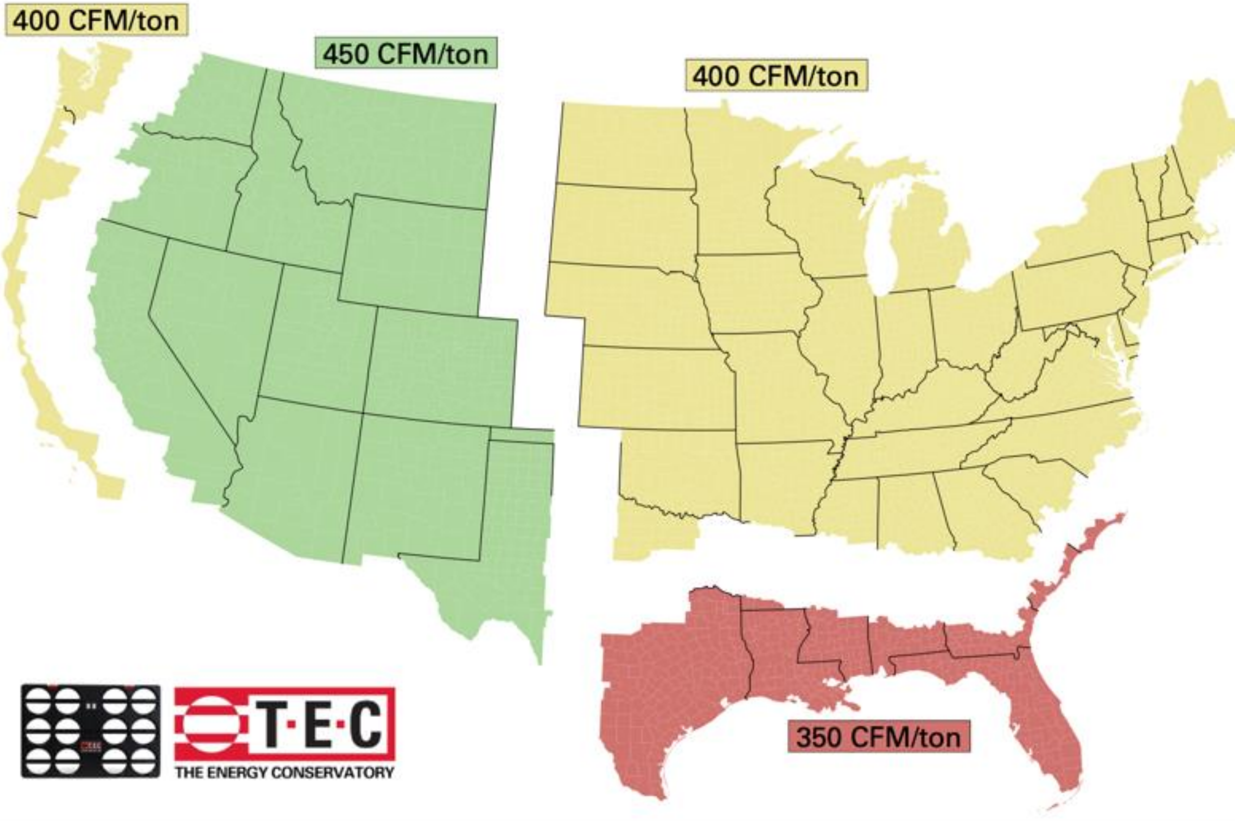
Air Conditioner Air Flow

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:

- **450 X 2.5 tons = ~1125 cfm**
- **450 x 3 tons = 1350 cfm 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

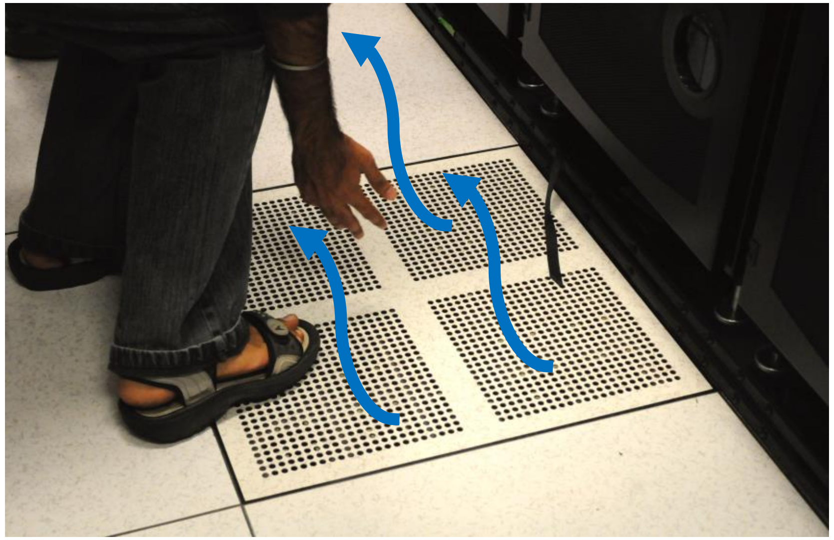
VCHP is 3-Ton

60 kbtu Gas furnace needs 900 CFM

2-Ton AC needs 900 CFM

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

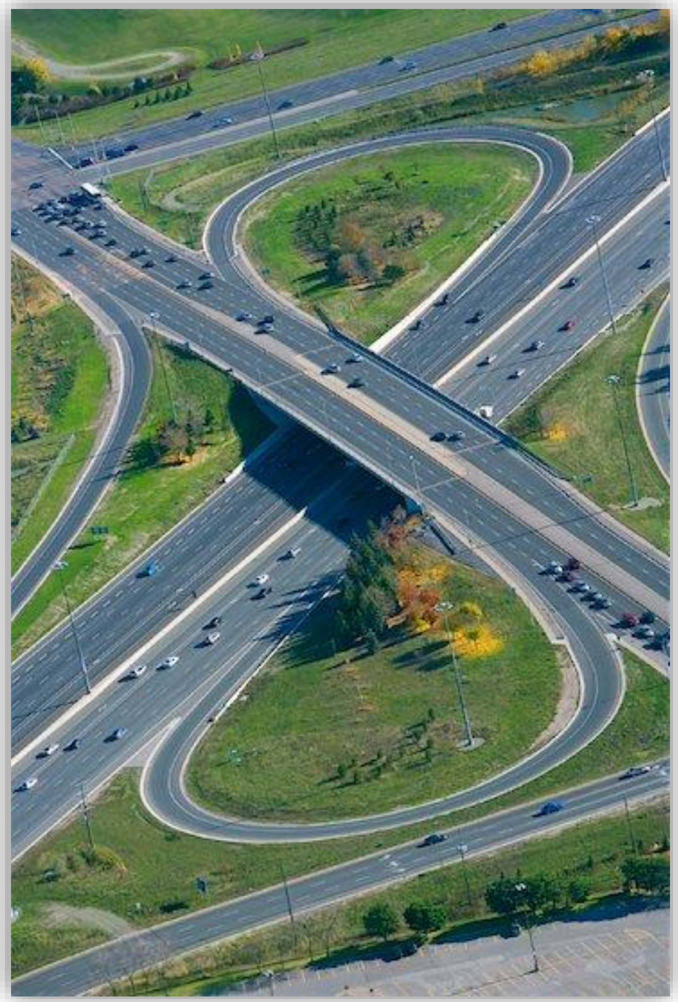
"Homer Simpson test" - Does warm air come out when calls for heating? Does cool air come out when calls for air conditioning?



Images courtesy Wikimedia Commons

NASCAR DUCT DESIGN

Airflow



Ductwork considerations

NOTE: Rule of Thumb ALERT

Total External Static Pressures

Most common to start with Total External Static Pressure

OEMs tell you ideal inches of water column

We may measure in Pascals

249 Pa per inch of water column

Every manufacturer is a bit different

We do this before replacement and check after installation

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

Inches of water column
Total External Static Pressure

Goodman ASPT39C14

Model	Speed Tap	Static Pressure (in w.c)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ASPT 25B14AB	1	640	585	580	545	510	490	410	340	280	
	2	800	765	725	700	670	645	595	565	490	
	3	840	805	800	760	740	700	670	625	580	
	4	985	950	920	885	850	815	800	760	725	
	5	1,475	1,440	1,400	1,375	1,335	1,305	1,270	1,240	1,150	
ASPT 29B14AB	1	595	590	565	530	505	455	380	305	260	
	2	790	775	745	705	665	625	585	515	445	
	3	865	820	790	770	735	695	645	595	530	
	4	1,015	980	955	925	880	840	795	770	720	
	5	1,505	1,465	1,430	1,410	1,385	1,350	1,315	1,285	1,220	
ASPT 49C14AC	1	1325	1280	1240	1200	1160	1115	1065	1025	985	
	2	1465	1420	1380	1355	1315	1280	1240	1195	1155	
	3	1505	1465	1425	1390	1355	1330	1290	1245	1205	
	4	1600	1565	1530	1490	1460	1425	1385	1365	1290	
	5	1690	1660	1625	1585	1555	1520	1485	1400	1250	

Shaded Area: Indicates “ranges in excess of maximum external pressure”

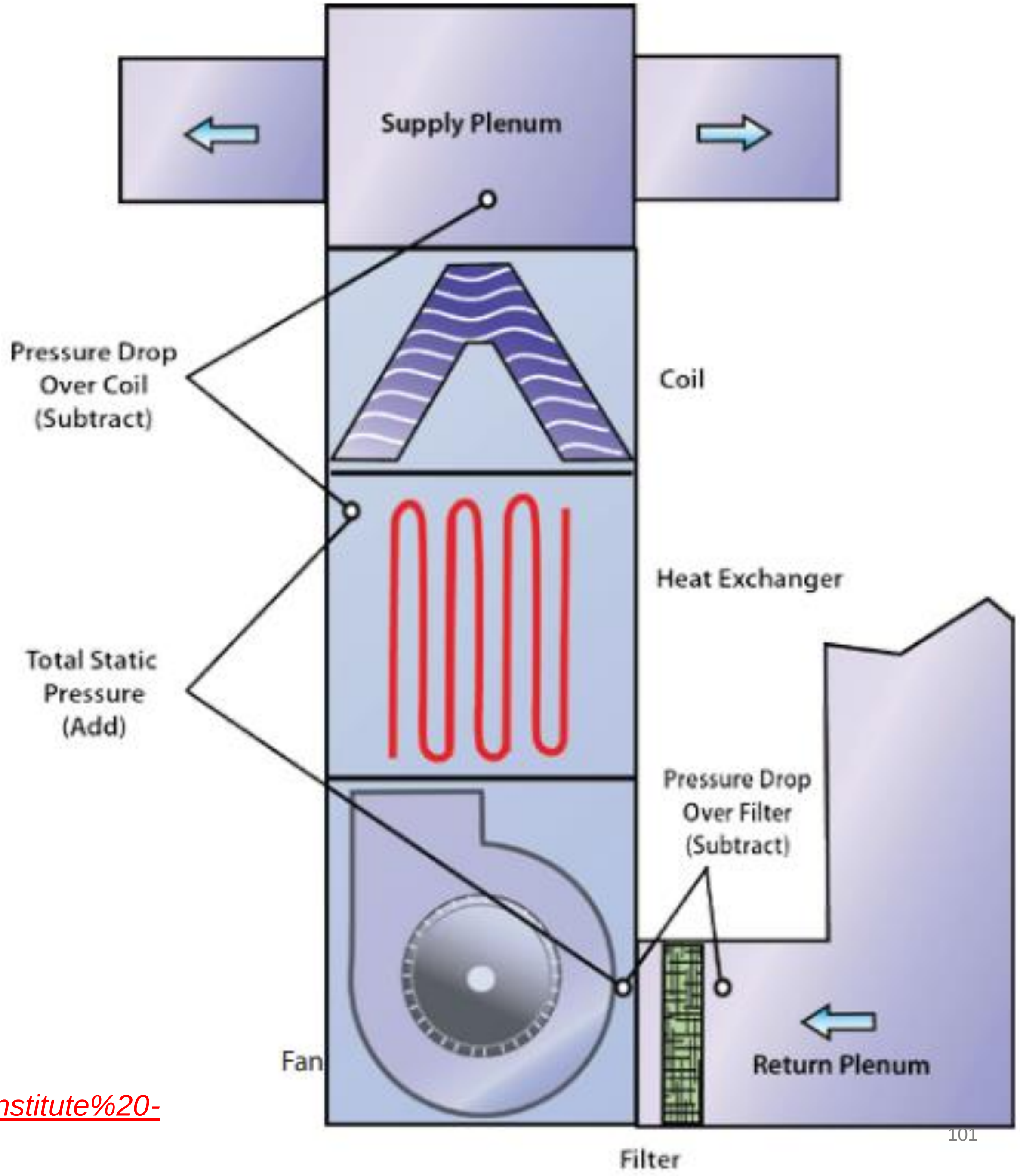
Notes:
- Airflow data indicated is at 230V without air filter in place.
- The chart is for information only. For satisfactory operation, external static pressure must not exceed value shown on rating plate. The shaded area indicates ranges in excess of maximum design external static pressure.
- Use the CFM adjustment factors of 0.98 for horizontal left and 0.96 for horizontal right & downflow orientations.
- When applying a humidistat (normally closed), refer to the installation and operating instructions. The humidistat can adjust the cooling airflow to 85%.

TESP and Fan Tables and what is meant by "External"

"External" designates how the unit was shipped:

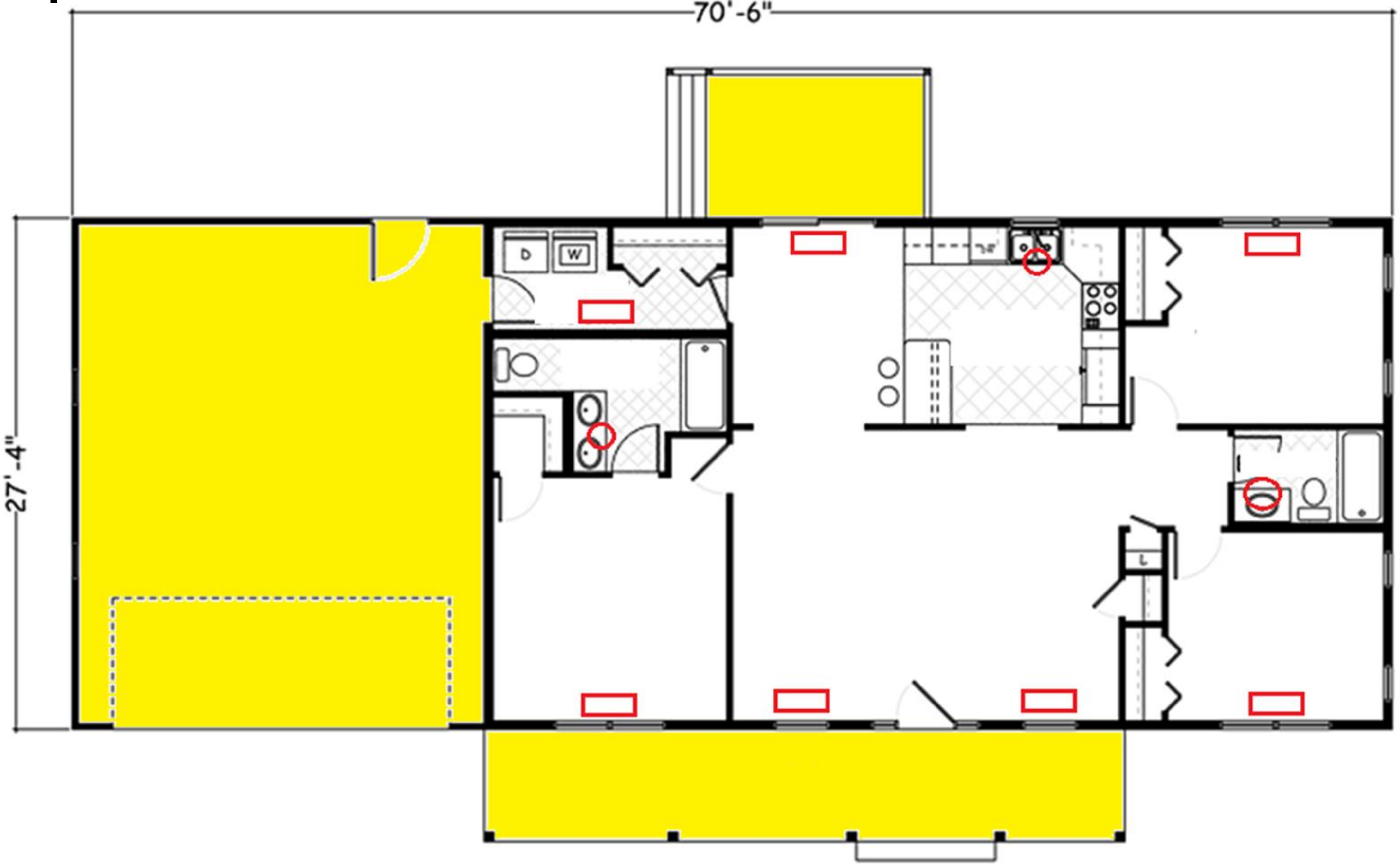
With a central heat pump utilizing auxiliary heat, the air handler and coil are shipped in one piece. The fan curves reflect this the resistance of the of the coil

With gas furnaces with an AC or HP coil, the coil is not shipped with the air handler. The fan curves in this case, do not reflect the resistance of the coil. When testing these systems, the supply side measurement MUST be furnaces taken before the coil



https://www.energystar.gov/sites/default/files/specs/National%20Comfort%20Institute%20-%20Measure%20and%20Interpret%20Static%20Pressures.pdf

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 (10cfm loss 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

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

Flex duct = .05" on most metal duct calculator

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

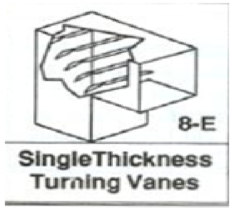
2 tons: 800 CFM/2 = 400 sq inches

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

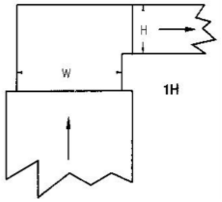
16x24 Ak 1.73	cfm Ps	519 0.016	692 0.032	865 0.052	1038 0.072	1263 0.097

What impacts air flow and static pressures? Comparison of Equivalent Lengths (ELs)



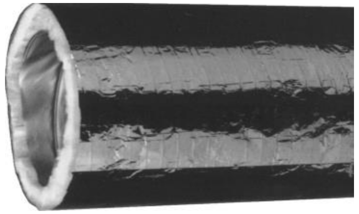
EL=10 feet

EL=20 feet



EL=120 feet

50 feet has an EL of 50 feet

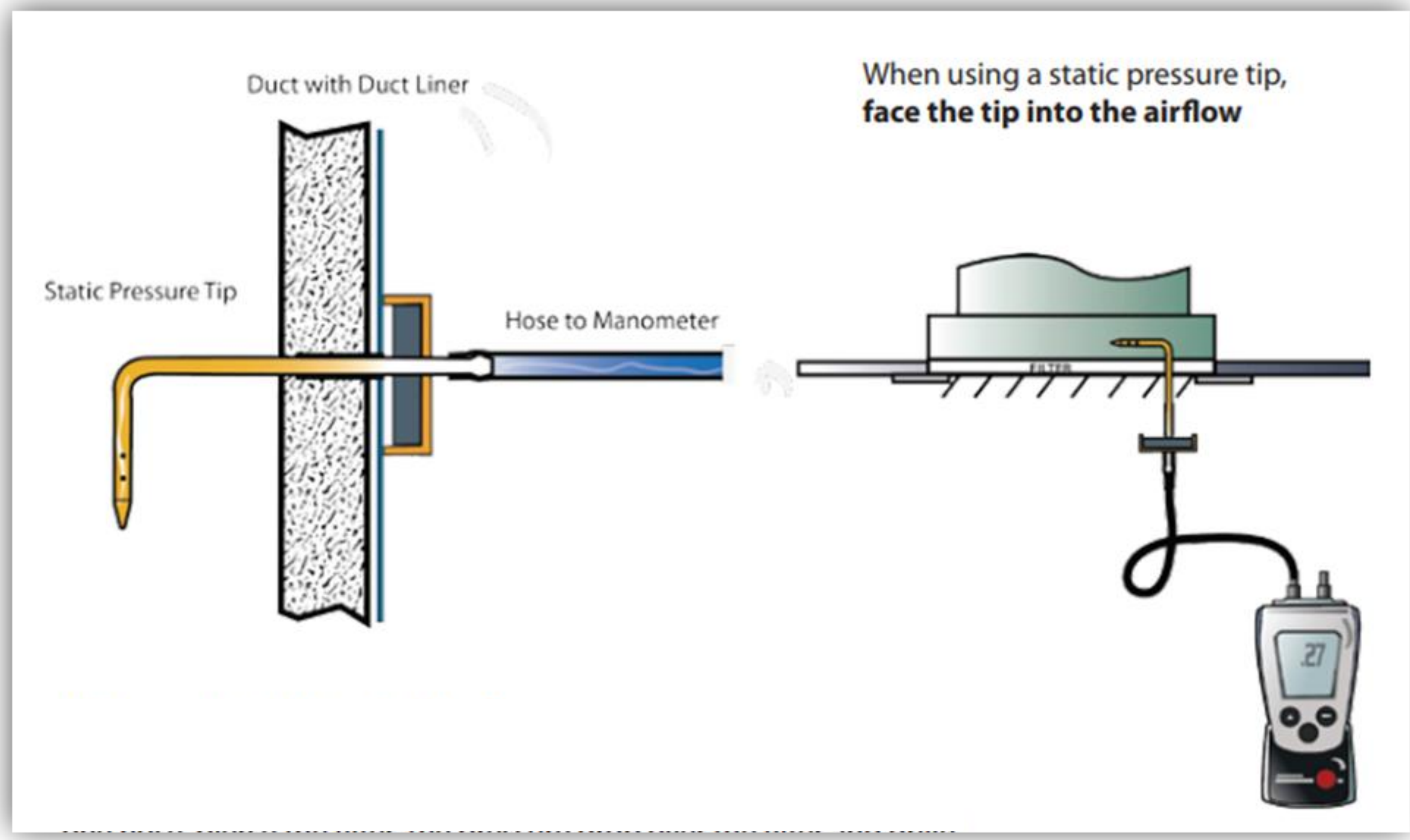


50 feet of 15% compressed flex has an EL of 100 feet

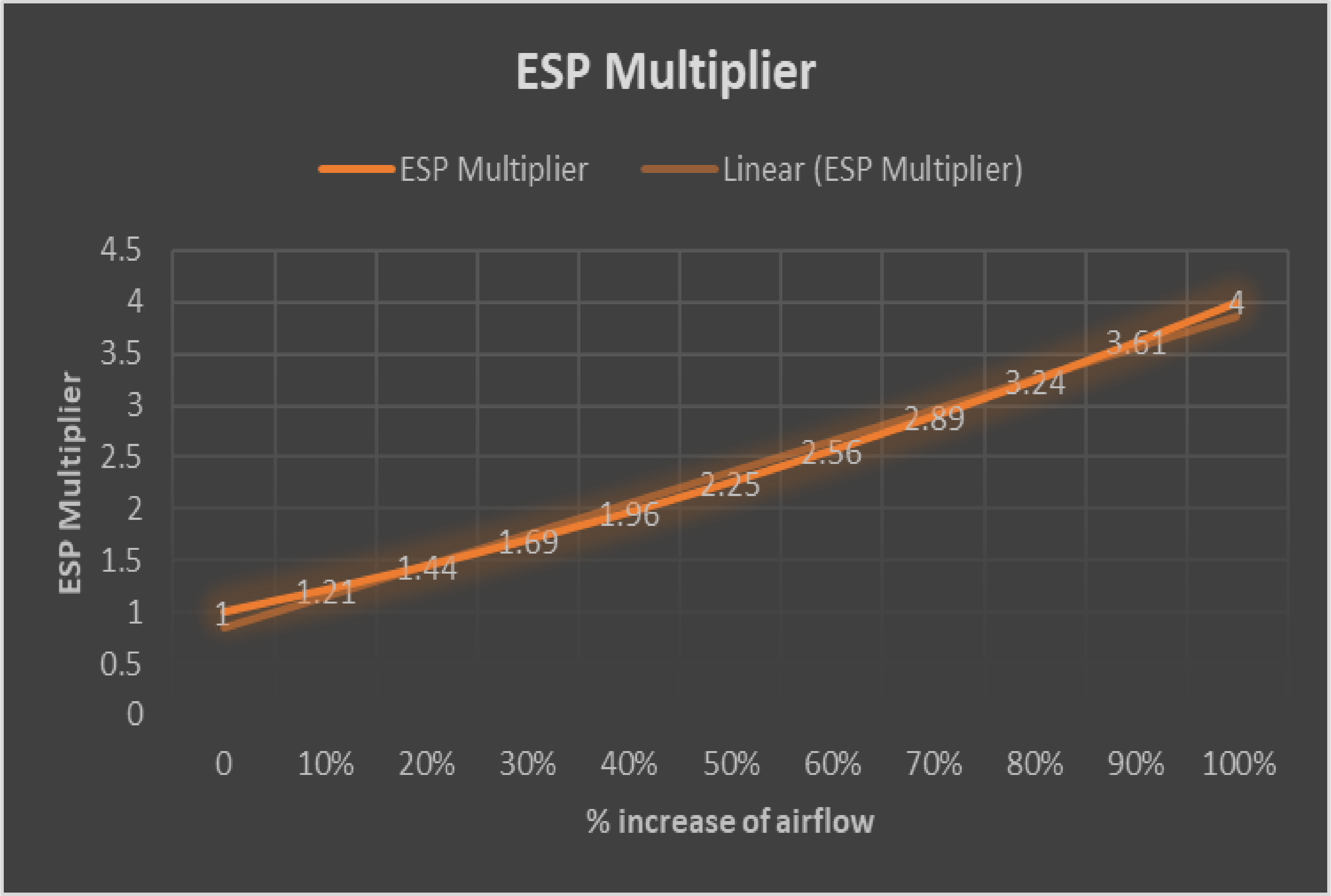
0 10 20 30 40 50 60 70 80 90 100 120

EL in Feet

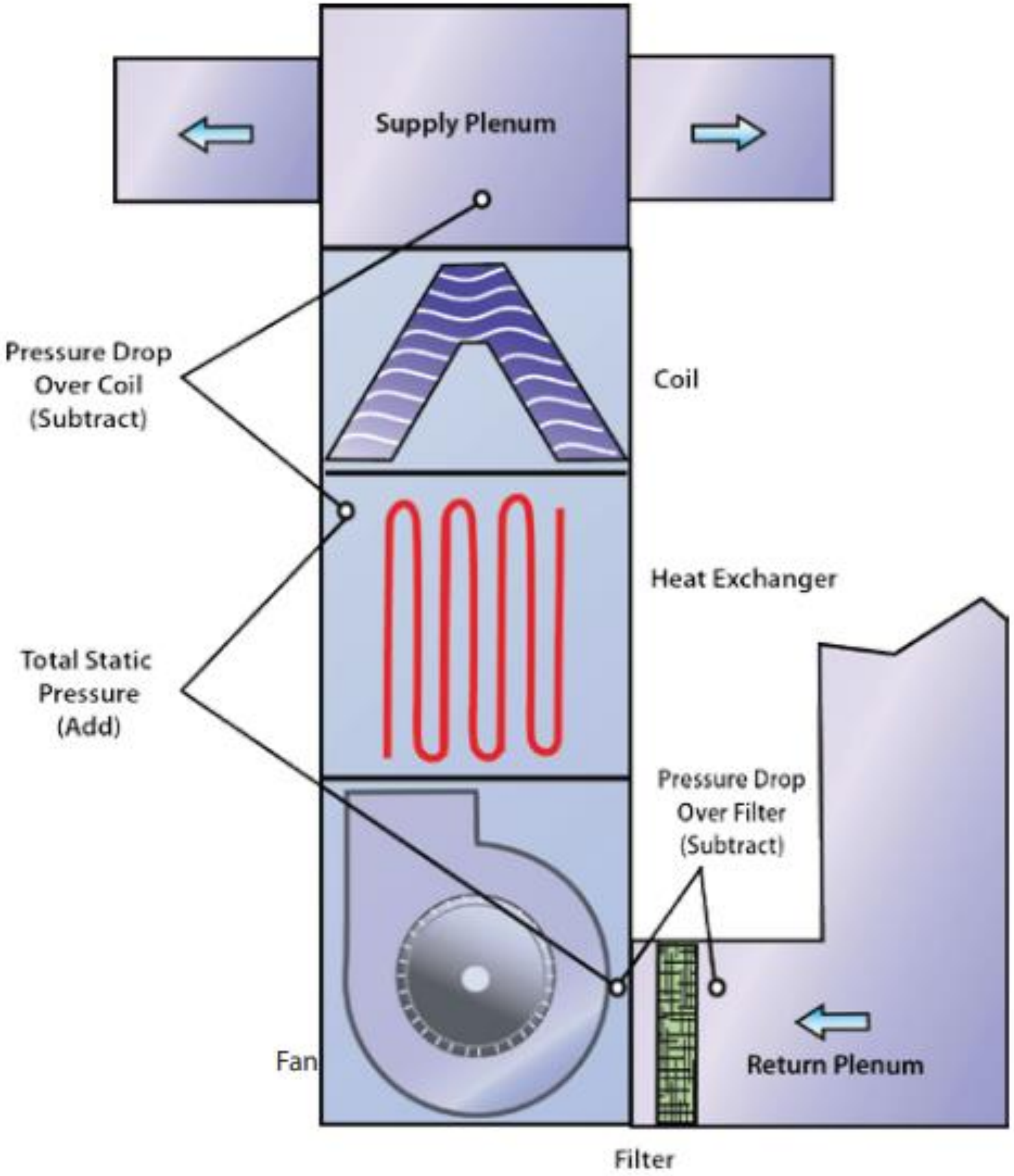
Measurements Must be Taken Static Pressure Tap



External Static Pressure Multiplier – thanks Bruce Manclark!



Doubling airflow *could* 4x your external static pressure!



Existing ESP = 0.4 inwc

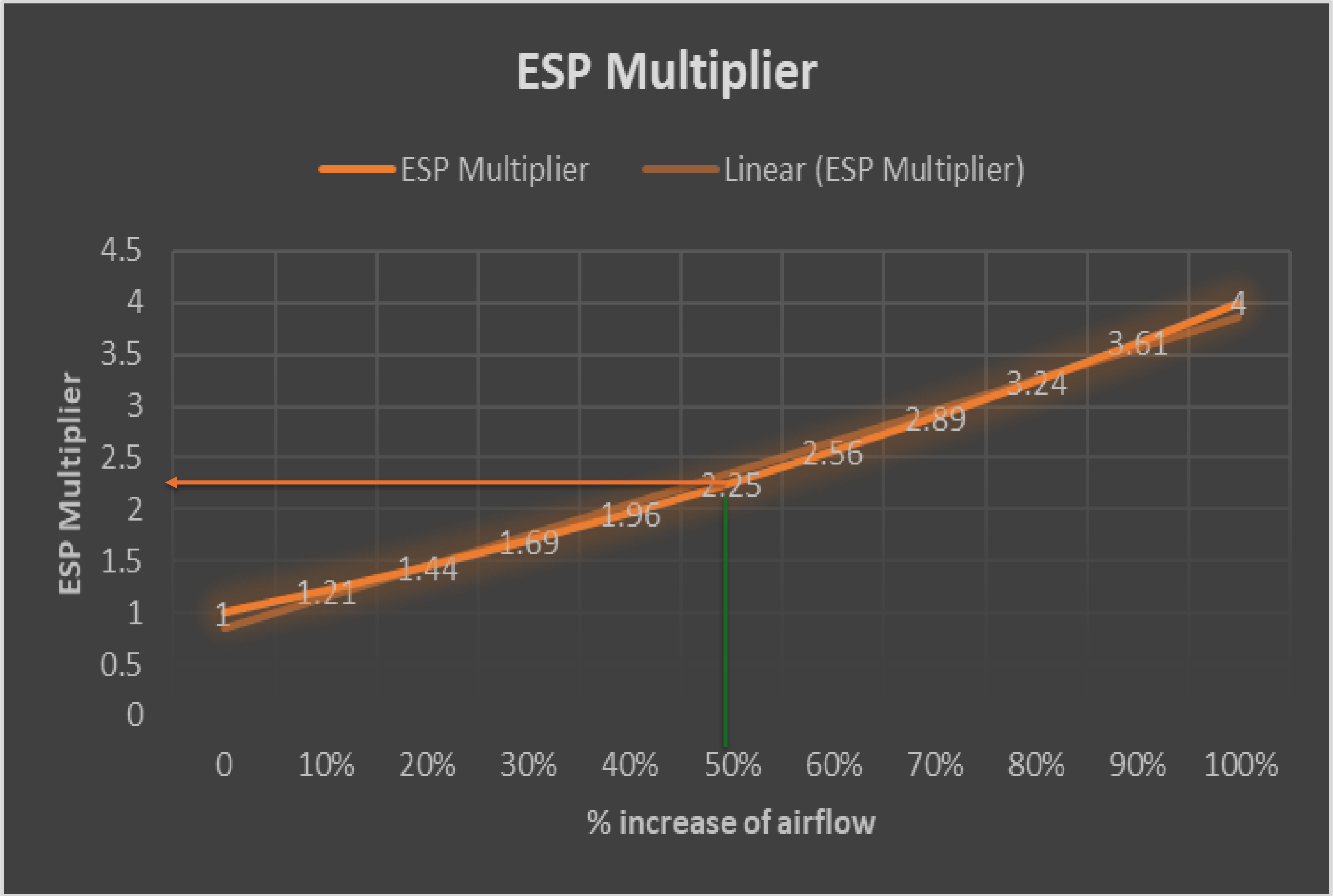
Available static pressure = 0.25

2-ton system

Airflow ~900 cfm

Can we put in a 3-ton system?

External Static Pressure Multiplier

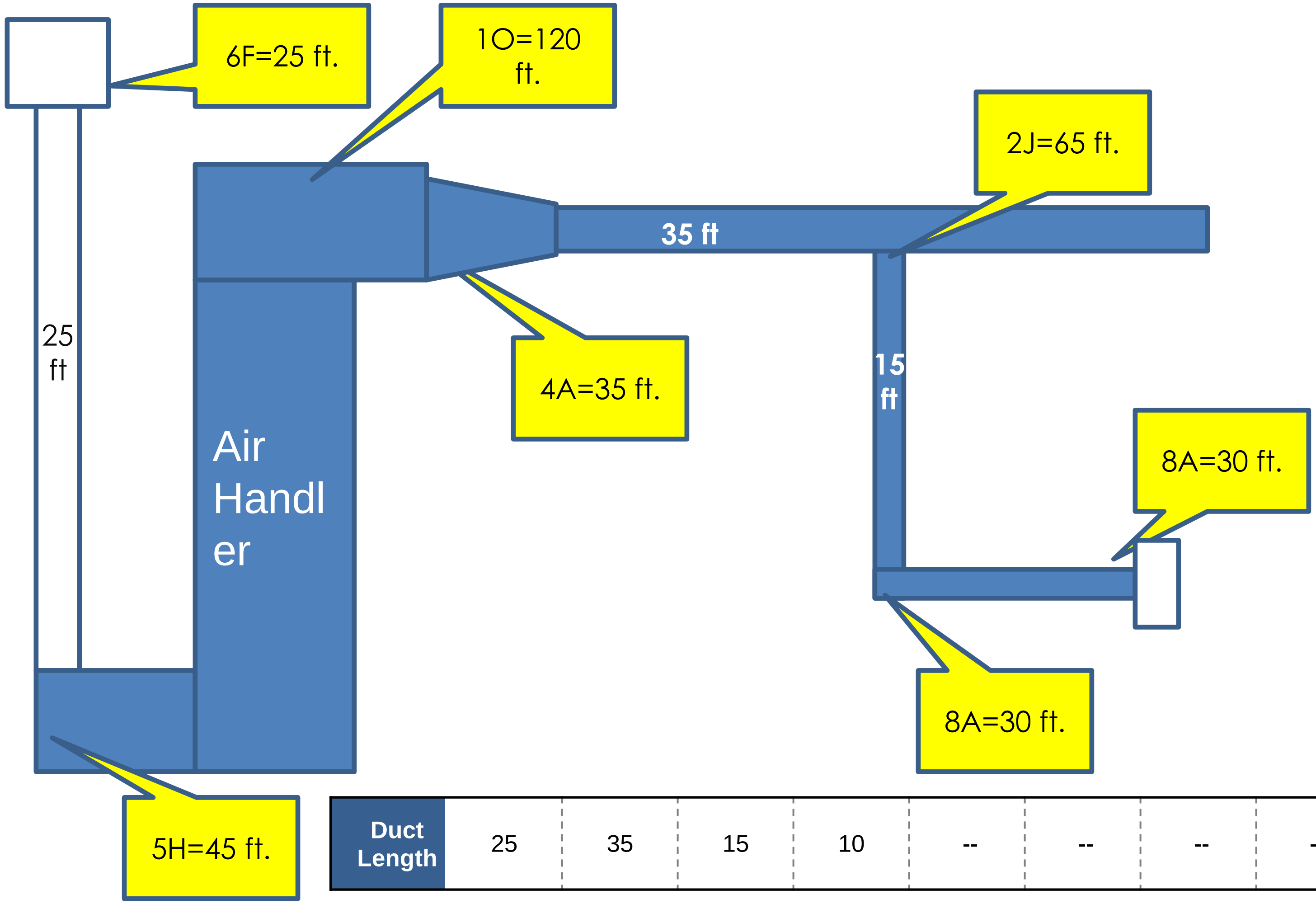


Going from 900 to 1350 cfm would be a 50% increase in flow

Static pressure would use an ESP multiplier of 2.25

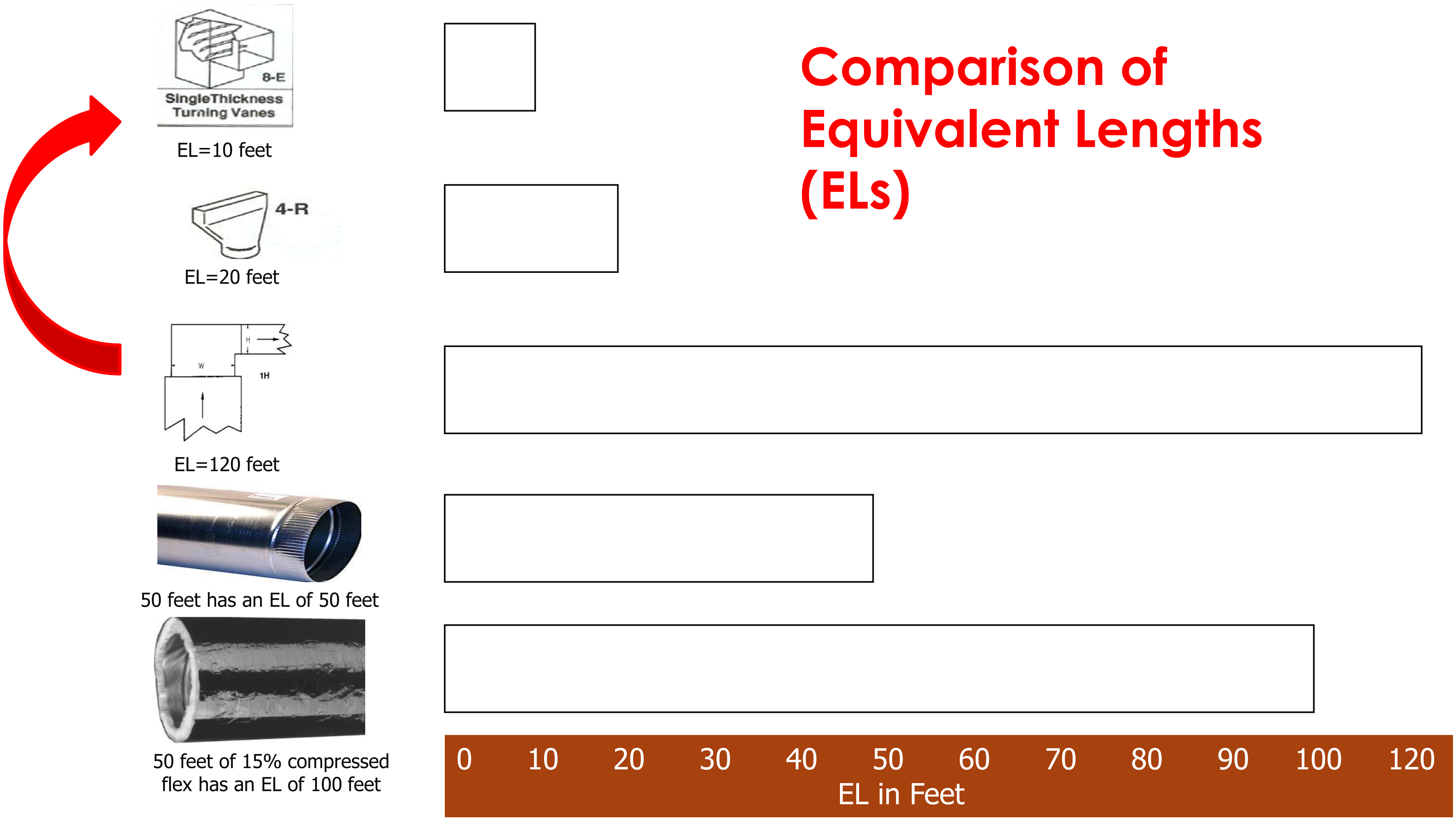
So, TESP would go from 0.4 to **1.0**

What can we do to lower this back to under 0.6?

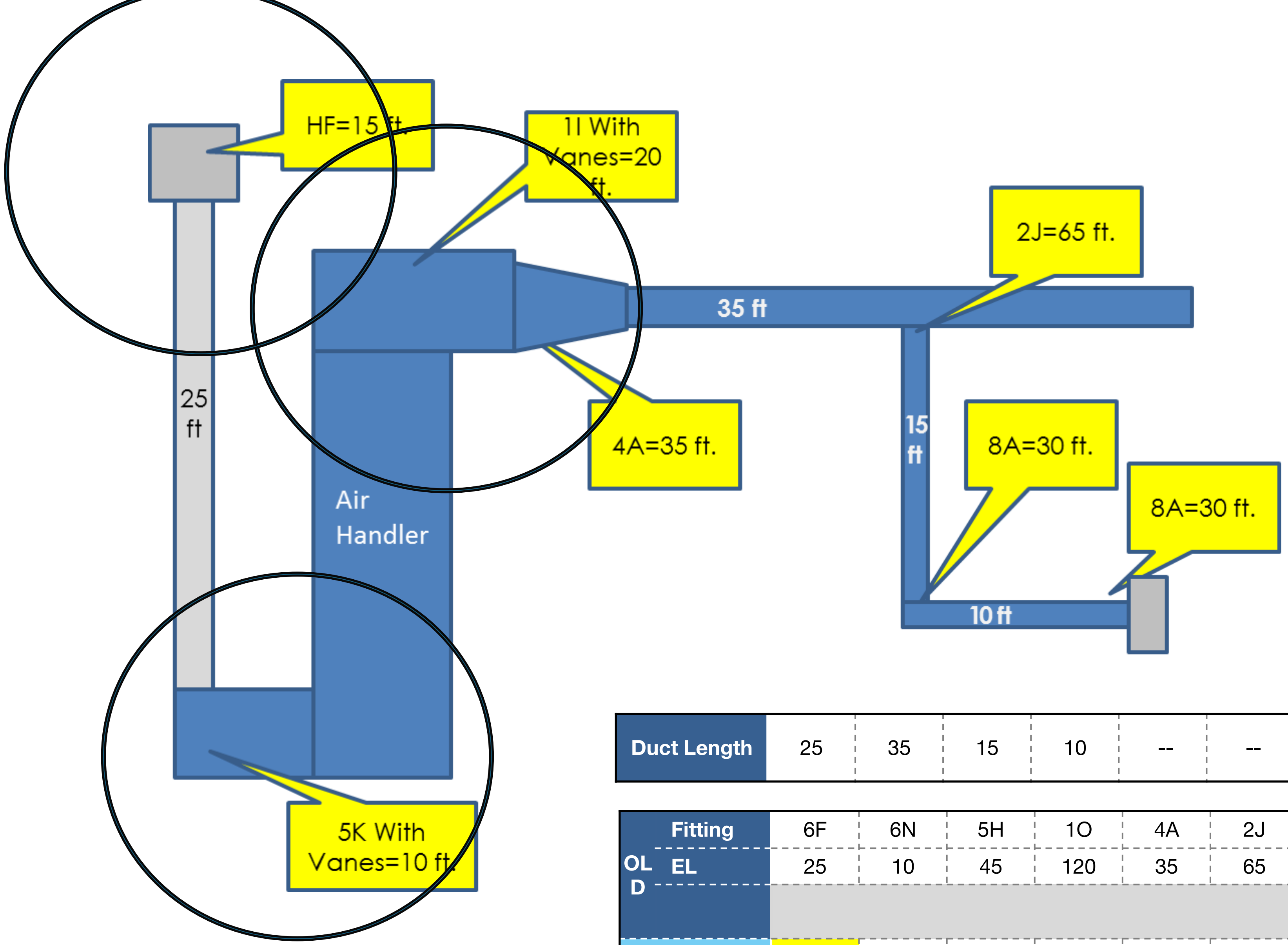


									Total
Duct Length	25	35	15	10	--	--	--	--	85

Fitting	6F	6N	5H	1O	4A	2J	8A	8A	--
EL	25	10	45	120	35	65	30	30	360
								Grand Total	445



Comparison of Equivalent Lengths (ELs)
8-E
SingleThickness Turning Vanes
EL=10 feet
4-R
EL=20 feet
H
W
1H
EL=120 feet
50 feet has an EL of 50 feet
50 feet of 15% compressed flex has an EL of 100 feet
0 10 20 30 40 50 60 70 80 90 100 120
EL in Feet



We can reduce the EL for the three easy to get big numbers.

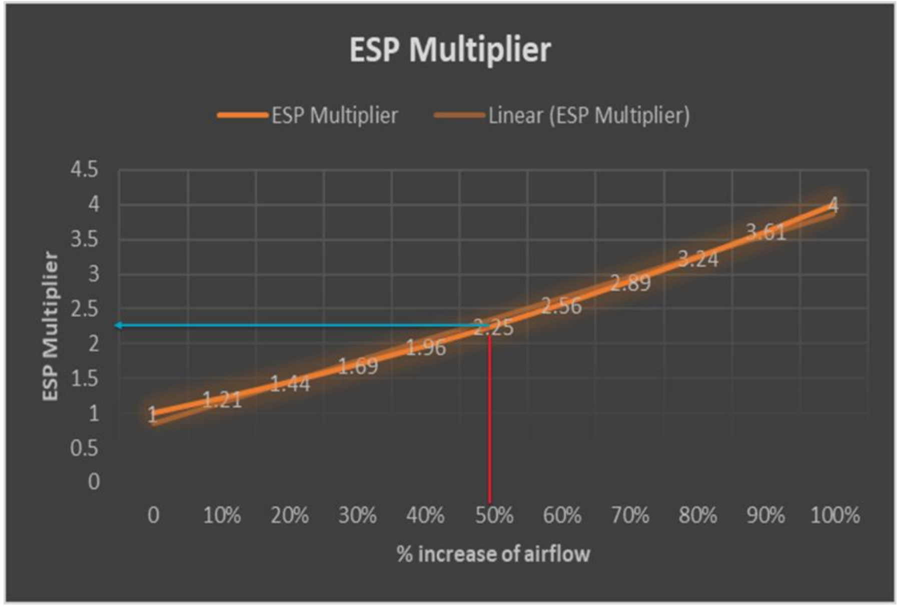
Then re-measured ESP

NEW ESP is 0.3 inwc

How does that look on our chart?

										Total
Duct Length		25	35	15	10	--	--	--	--	85
OLD	**Fitting**	6F	6N	5H	1O	4A	2J	8A	8A	--
	EL	25	10	45	120	35	65	30	30	360
									Grand Total	445
NEW	**Fitting**	HF	6N	5K	1I	4A	2J	8A	8A	--
	EL	15	10	10	20	35	65	30	30	215
									Grand Total	300

External Static Pressure Multiplier



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

Multiply our 0.3 x our 2.25 ESP multiplier gets us = **0.65**

Does that work for folks?

*Two models exist, modern Bluetooth and original model

Measuring airflow

Static Pressure Drop

Fairly easy

Can be a part of TEC airflow testing or measureQuick commissioning

Must use correct equipment

Is moderately accurate

True Flow Plate*

Easy to use

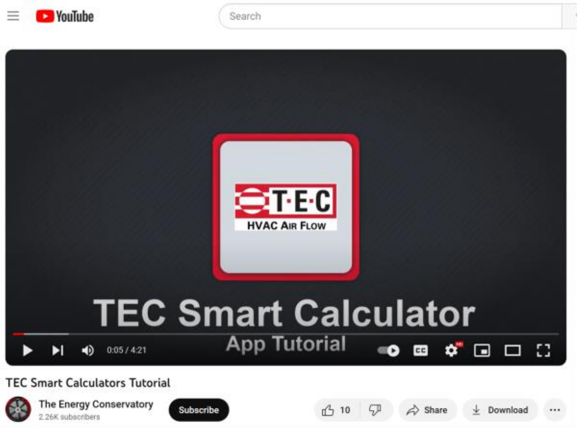
Requires upfront cost of purchase of True Flow

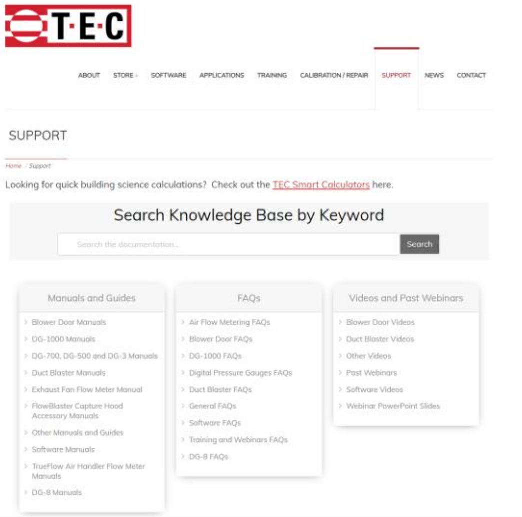
Very accurate

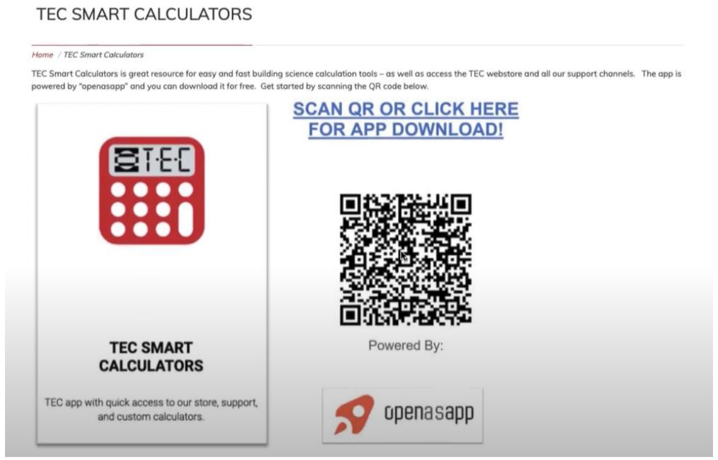
Easily fits into TEC Airflow app and measureQuick app

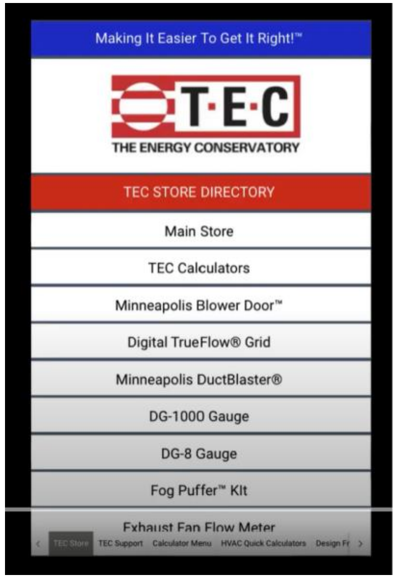
Aligns with Standard 310 and Standard 5

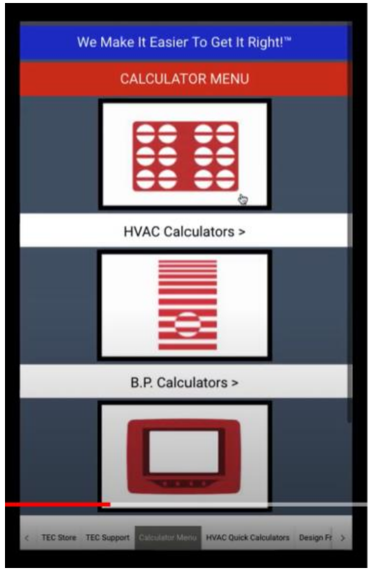
From The Energy Conservatory







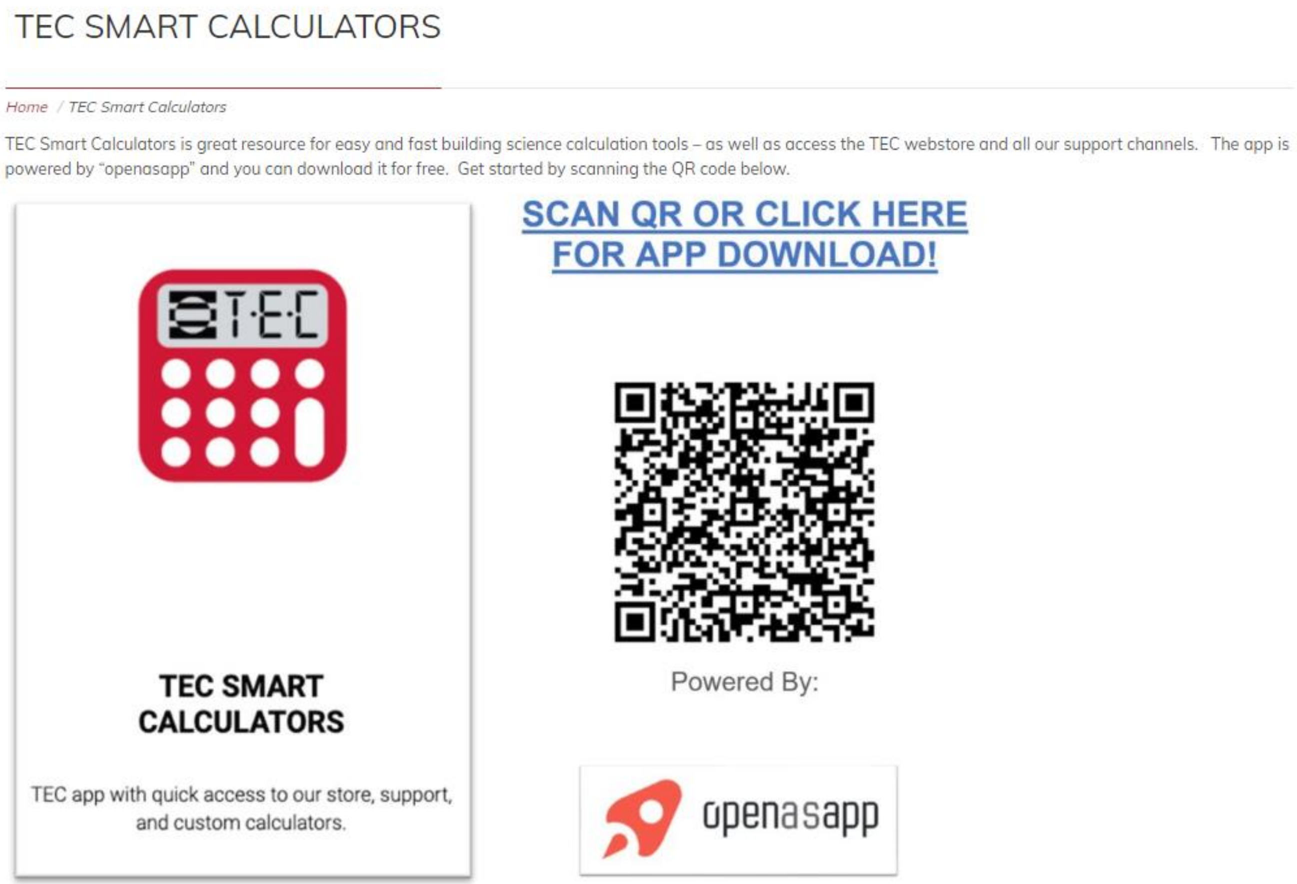




[TEC Smart Calculators Tutorial]

[TEC Demonstration Video for TESP Testing]

Let’s download the app!


TEC SMART CALCULATORS

Home / TEC Smart Calculators

TEC Smart Calculators is great resource for easy and fast building science calculation tools – as well as access the TEC webstore and all our support channels. The app is powered by “openasapp” and you can download it for free. Get started by scanning the QR code below.

TEC SMART CALCULATORS

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Or we can use the web version!

https://webclient.openasapp.net/portal#!/client/app/e4432df8-f960-4ba1-8003-f3d43df56056

CAN THE EXISTING DUCT SYSTEM HANDLE THE AIRFLOW?

Summary

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

If not;

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

Recommended practices for sizing - Key takeaway's

- Load calculations already have safety factors built in. There's no need to use estimations that increase the load calculation!
- Recommended load calculations include:
  - Energy bill or runtime analysis
  - Block load calculations
- Oversized systems may struggle with existing ductwork.
- Oversized systems will cost more to run.

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Break

15 min

Center for Energy and Environment

New Tools and Resources

Myth – Its hard to estimate costs

What determines costs?

- The building itself and its location
- Rates for gas and electricity
  - Demand impacts
- Equipment performance and efficiency
- Occupant behavior
- Is weatherization happening?
- Future costs - where do YOU think gas and electric rates are heading?

Design Decision Methods Identify Customer's Needs

- Interest/willingness for doing load reduction measures first
- Desire to stop using fossil fuels
- Occupancy patterns (long spells away from home vs. consistently occupied)
- Do they want cooling throughout the house or just in certain rooms?
- Cost concerns
  - First cost vs. ongoing fuel and maintenance costs
- Plans for renovations or additions

Listen to Hurts, Needs and Wants

67%

Are unsatisfied or somewhat unsatisfied
with their ***current*** heating system

source: 6th annual NW DHP Project Market Progress Report

Customer opportunities and perceptions

Goals of market research

Uncover homeowner perceptions

- What do customers values?
- What drives system replacement?
- Where are current awareness levels?

Understand opportunities and barriers

- What do these look like for contractors?
- …Distributors?
- …Manufacturers?

Activate growing business opportunity

- ASHPs as AC replacements present a clear business opportunity.
- While homeowners are beginning to hear more about heat pumps, there is an opportunity to close the knowledge gap
- Learn how to communicate both benefits and costs in ways that are easiest for homeowners to understand

What saves energy with heat pumps?

- Efficiency of Unit
  - Particularly the COP at minimum capacity at 47ºF and for all electric systems the COP at winter design temperatures (assuming system is sized, designed, and installed correctly).
- QI process and proper commissioning
- Controls strategies
  - Switchover temperatures
  - Control over backup heat
- Drain pan heaters and crankcase heaters
- Defrost cycle
- “Zombie loads”
  - Onboard computers communication devices, and electrified control boards

Customer insights

- Before being explained, 40-55% of interviewed homeowners are aware of how heat pumps differ from air conditioners

- After heat pump benefits were explained, about **half of interviewed homeowners said “saving money” was a motivation** and almost a third said “hearing good things about heat pumps” motivated them.

- **After heat pump benefits were explained, almost 80% of homeowners said that they would pay up to 20% more for a heat pump that delivered on performance claims.**

- For those that purchased heat pumps, **homeowners recommended heat pumps due to saving money,** better efficiency, reduced emissions, and better cooling performance.

New systems should not increase costs for homeowners without their notice!

1. Dual Fuel Systems can be set to cost the same or less than a gas furnace with an AC
2. Homeowner desires for comfort, IAQ, carbon savings, or other drivers may supercede operational cost
3. Systems settings can be changed annually (or more often) to best address comfort and energy bills

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

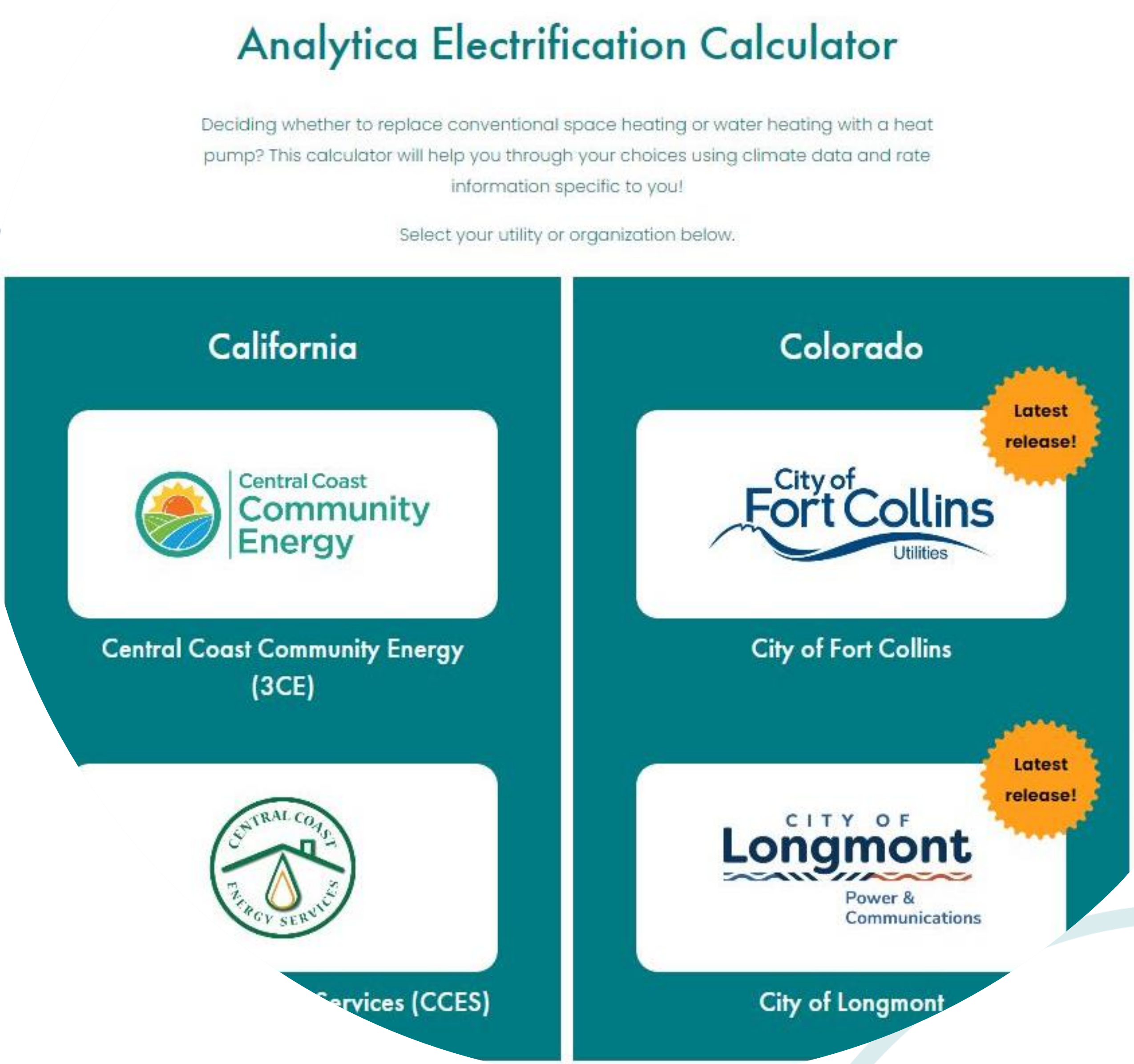
- The outdoor or indoor temperature at which the cost to heat the home with the HP is the same or more expensive than the back up heat cost.
- Relies on the primary and back up heat fuel cost.

Comfort balance point

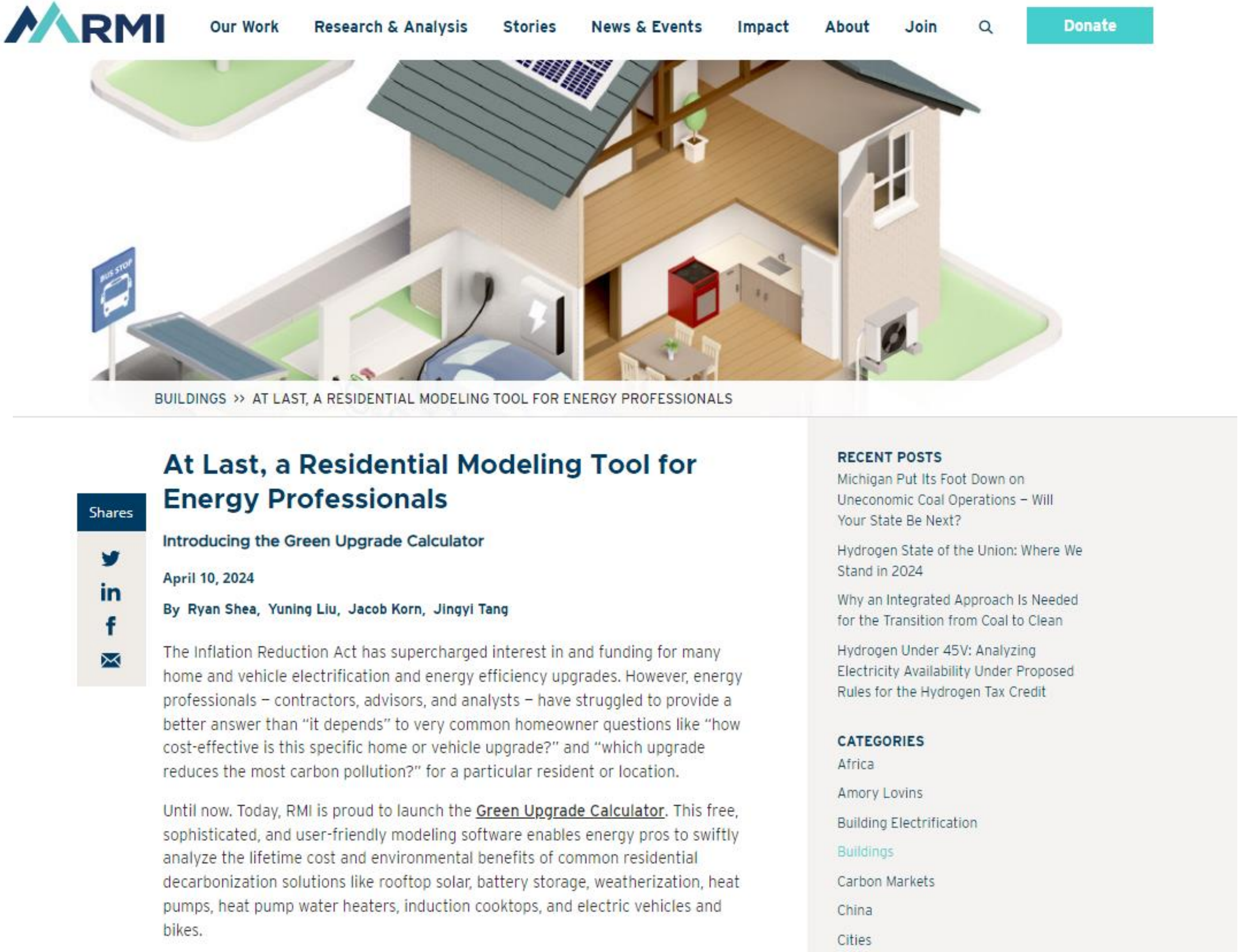
- The outdoor temperature at which the homeowner experience discomfort when running the heat pump.

Analytica Electrification Calculator

- Brought to you by Lumina
- Used in some capacity by City of Fort Collins and City of Longmont
- A heat pump and heat pump water heater calculator!



Green Upgrade Calculator



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BUILDINGS » AT LAST, A RESIDENTIAL MODELING TOOL FOR ENERGY PROFESSIONALS

At Last, a Residential Modeling Tool for Energy Professionals

Introducing the Green Upgrade Calculator

April 10, 2024

By Ryan Shea, Yuning Liu, Jacob Korn, Jingyi Tang

Shares

The Inflation Reduction Act has supercharged interest in and funding for many home and vehicle electrification and energy efficiency upgrades. However, energy professionals – contractors, advisors, and analysts – have struggled to provide a better answer than "it depends" to very common homeowner questions like "how cost-effective is this specific home or vehicle upgrade?" and "which upgrade reduces the most carbon pollution?" for a particular resident or location.

Until now. Today, RMI is proud to launch the Green Upgrade Calculator. This free, sophisticated, and user-friendly modeling software enables energy pros to swiftly analyze the lifetime cost and environmental benefits of common residential decarbonization solutions like rooftop solar, battery storage, weatherization, heat pumps, heat pump water heaters, induction cooktops, and electric vehicles and bikes.

RECENT POSTS

Michigan Put Its Foot Down on Uneconomic Coal Operations – Will Your State Be Next?

Hydrogen State of the Union: Where We Stand in 2024

Why an Integrated Approach Is Needed for the Transition from Coal to Clean

Hydrogen Under 45V: Analyzing Electricity Availability Under Proposed Rules for the Hydrogen Tax Credit

CATEGORIES

Africa

Amory Lovins

Building Electrification

Buildings

Carbon Markets

China

Cities

New RMI Calculator - Inputs

Home Design

Home Conditioned Stories	2

Which home weatherization improvements have already been added to the home?

Added Insulation | Sealed Air Leaks | Replaced Windows

SHOW ADVANCED INPUTS

Current Wall R-Value (F-ft²-hr/BTU)	9
Current Attic or Ceiling R-Value (F-ft²-hr/BTU)	30

Energy Rates

Electricity Rates

Electric Utility	State Average Rate
Electric Volumetric Rate: Traditional Scenario ($/kWh)	0.143
Electric Volumetric Rate: Green Upgrade Scenario ($/kWh)	0.143
Monthly Fixed Charge: Traditional Scenario ($/month)	12
Monthly Fixed Charge: Green Upgrade Scenario ($/month)	12
Annual Volumetric Rate Increase (%/year)	1.9

Natural Gas Rates

Natural Gas Volumetric Rate ($/ccf)	1.18
Monthly Fixed Charge: Traditional Scenario ($/month)	15
Annual Retail Rate Increase (%/year)	4.7

Space Cooling and Heating

Green Upgrade - Air-Source Heat Pump

Number of Outdoor Units	1
Size per Outdoor Unit (Tons)	2.0

For reference, this heat pump size is estimated to cover 87% of your home's annual heating load, with the rest covered by a backup heating element.

Listed HSPF2	9
Listed SEER2	18
Heat Pump Switch Off Temperature Setting (°F)	20

Traditional Replacement - Ducted Central AC

Number of Outdoor Units	1
Size per Outdoor Unit (Tons)	2.0
Listed SEER2	14.5

Green Upgrade Calculator

Version 1.2

Our Partners FAQ API Contact Us Reset Analysis

ECONOMIC IMPACT **CLIMATE IMPACT**

My Selection [Save Analysis]

Green Upgrades: Electric Air-Source Heat Pump - Ducted Central [Edit]

Traditional Replacements: Ducted Central AC, Natural Gas Furnace [Edit]

My Impact

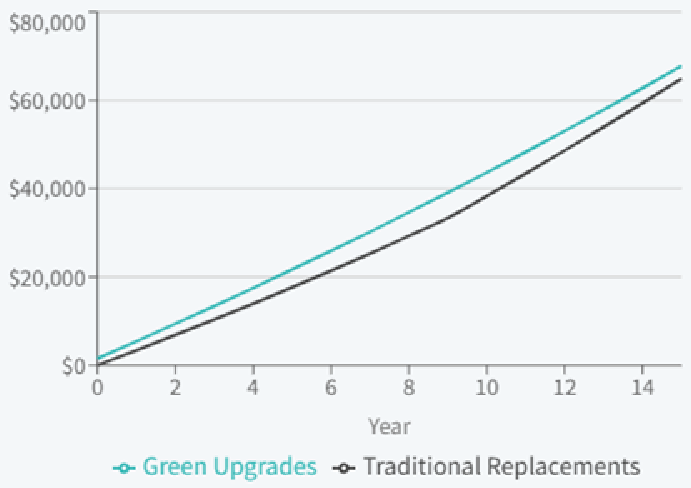
Timeframe: 15 years

Upfront Costs Increased by $15,940

Annual Costs in the First Year Lowered by $302

Lifetime Costs Increased by $2,901

Total Cumulative Costs



Green Upgrade Calculator

Version 1.2

Our Partners FAQ API Contact Us Reset Analysis

ECONOMIC IMPACT | **CLIMATE IMPACT**

My Selection [Save Analysis]

Green Upgrades: Electric Air-Source Heat Pump - Ducted Central [Edit]

Traditional Replacements: Ducted Central AC, Natural Gas Furnace [Edit]

My Impact

Timeframe: 18 years

Upfront Costs Increased by $15,940

Annual Costs in the First Year Lowered by $372

Lifetime Costs Lowered by $2,986

Colorado State Energy Office Options

- Federal Tax Credits (25C) – Up to $3,200/year
  - Qualifying Heat Pumps – up to $2,000/year
  - HPWHs – up to $2,000/year
  - Weatherization – up to $1,200
  - Electric panel upgrades – $600 per property
- State Tax Credits – Contractors submitted
  - Qualifying Heat Pumps - $1,500
    - Minimum required customer discount - $499.95
  - Heat Pump Water Heater - $500
    - Minimum required customer discount - $166.65

CEE1 New Resources Finalized

- Duct Retrofit Decision Guide
    - Inadequate ducts can significantly reduce the performance of air source heat pumps (ASHPs). Repurposing existing ducts for heat pump use requires thoughtful sizing and duct-quality considerations. This guide informs contractors on how to determine when ducts should be fixed or abandoned.
- System Design with Existing Heating
    - Adding a heat pump to a building with a legacy system introduces several new design and operation considerations. These challenges include different operating costs, division of capacity between the systems, interaction between the systems, and when to run each system. This document describes potential applications for heat pumps in houses with functional legacy heating systems.
- Weatherization Guide – Homeowner Version | Contractor Version
    - Heat pumps run more efficiently in buildings that are sufficiently weatherized. Air sealing, insulation, and upgrading windows can also lower the capacity needed, thereby simplifying the heat pump distribution design requirements and lowering the cost of installing and operating a heat pump. These documents outline the benefits of weatherization before installing a heat pump.

CEE1 New Resources Finalized

- You Installed a Heat Pump, What Now?
  - Heat pumps operate differently than either electric resistance or fossil fuel heating systems. Expectation setting should be as proactive as possible. Proper education around usage and maintenance can help ensure that customers are satisfied with their heat pumps. This document addresses basic information, operation, maintenance, controls settings, and frequently asked questions. It is intended to teach a new heat pump owner or potential heat pump owner all they need to know to operate their heat pump safely and efficiently.
- Heat Pump Design Decision Matrix and System Design Guide | Web Based Widget
  - The decision-making process around heat pump installations is complex. For both customers and contractors who are less familiar with the options, there is a need to clearly describe the factors that will lead to appropriately implemented systems. Distribution methods can be difficult to choose from, and the options can be overwhelming to homeowners, especially for emergency replacements, when they have little planning time. This resource is a comprehensive workflow that simplifies heat pump installations into a series of decisions based on site conditions and customer needs. It is available both as full descriptive guide and as a web-based widget.
- Two-System Controls Guide – Homeowner Version | Contractor Version
  - Awareness of integrated controls is a limiting factor in their adoption. Homeowners are often unaware of what integrated controls are, what situations would benefit from integrated controls, and how to operate them. Contractors are more likely to be familiar with the technology, but they are unaware of best practices and value propositions. These documents describe integrated controls, best practices, and their value proposition.

Lunch

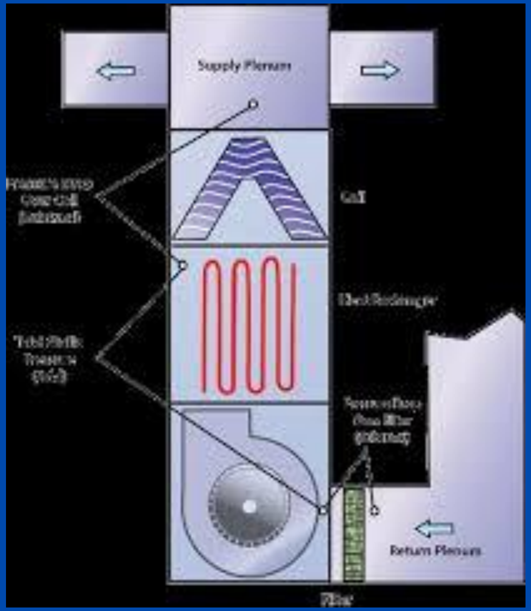
40 min

Rapid Deployment Assessments

Aka "30 minutes or less"

Center for Energy and Environment

What can we do in..



Ask the experts!

Joe Medosch and I asked our industry friends:

If you were told you only had 30 minutes or less and you have, a smartphone/tablet (w/Apps), a digital manometer and tubing, static pressure probes, a flashlight, a ladder, a roll of paper towels, and a cordless drill/screwdriver, some additional handheld tools...

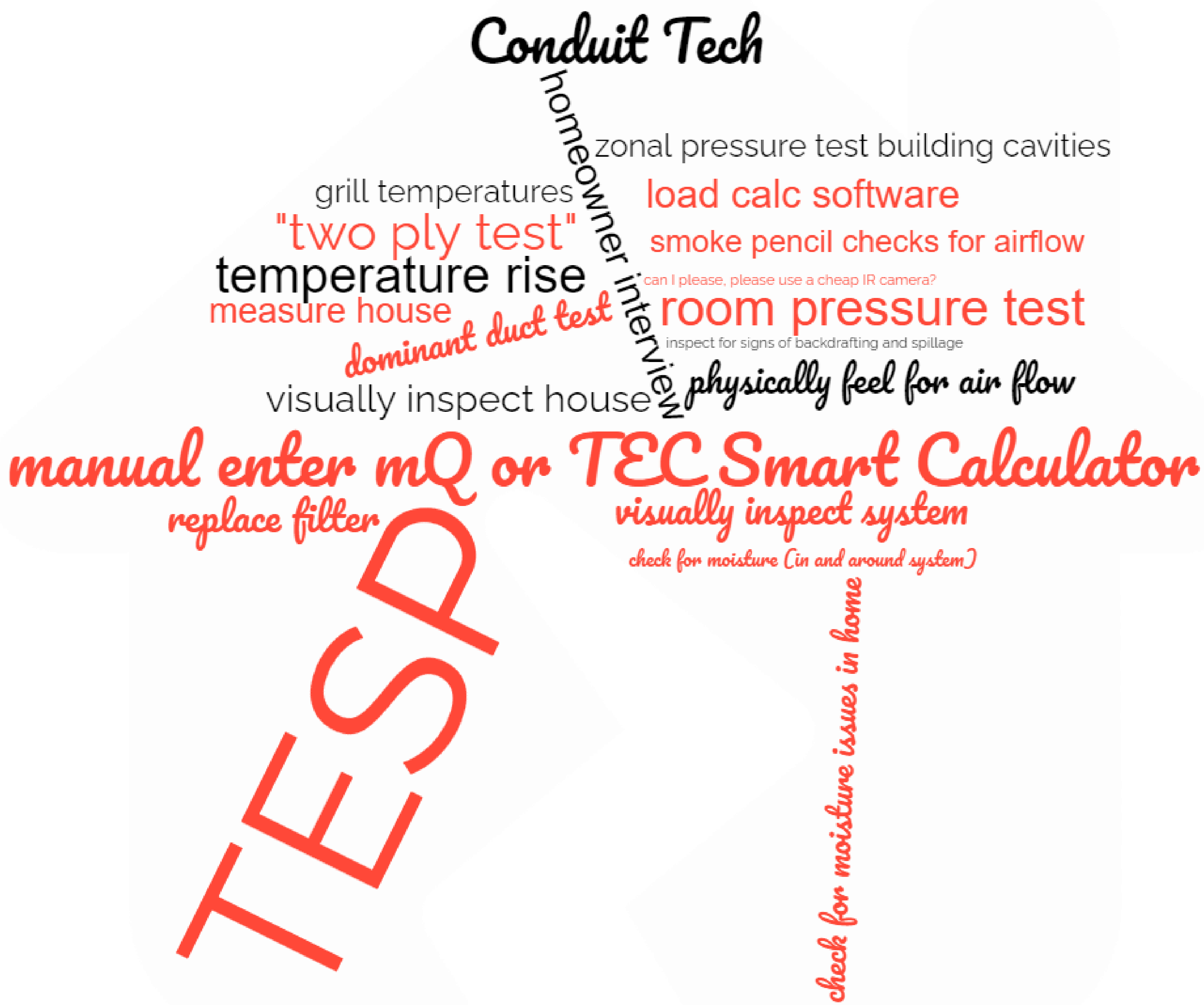
What tests or assessments would you make to deliver the most value to a home site visit?

The Stuff -

- a smartphone/tablet (w/Apps),
- a digital manometer and tubing,
- static pressure probes,
- a flashlight,
- a ladder,
- a roll of paper towels,
- and a cordless drill
- screwdriver,
- some additional handheld tools...

What does HVAC stand for?


WHAT?


Conduit Tech
homeowner interview
zonal pressure test building cavities
grill temperatures
load calc software
"two ply test"
smoke pencil checks for airflow
temperature rise
can I please, please use a cheap IR camera?
room pressure test
measure house
dominant duct test
inspect for signs of backdrafting and spillage
physically feel for air flow
visually inspect house
manual enter mQ or TEC Smart Calculator
replace filter
visually inspect system
check for moisture (in and around system)
TESP
check for moisture issues in home

What did others have to say? ~30 Survey Responses

Bruce Manclark
Tim Portman
Steve Rogers
Dustin Coles
Bill Spohn
Corbett Lunsford
Ed Janowiak
Jim Bergmann
Billy Spohn

Michael Housh
Kim DeVoe
Chris Conway
Russ King
Rick Hall
Adam Mufich
Rob Minnick
Stephen Rardon
Casey Phillips

Bill Fisher
Cody Brasseal
Tim DeStasio
Ben Baca
Alex Meaney
Kenneth Budka
Chris Hughes
Sam Myers
Shawn LeMons
James Jackson

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Some of our favorite answers/quotes

"I'll preface this by saying it takes me four times as long to do these work flows as Jim Bergmann and Chris Hughes take in their videos." – Kenneth Budkha

"TALK TO THE OCCUPANTS, AGAIN" – Corbett Lunsford

"Also record Room WRT main home pressures to determine MAD AIR conditions." – Dustin Cole

"Then I would conduct the Homer Simpson duct issue test, does conditioned air come out of the intended places?" – Bruce Manclark

More good quotes…

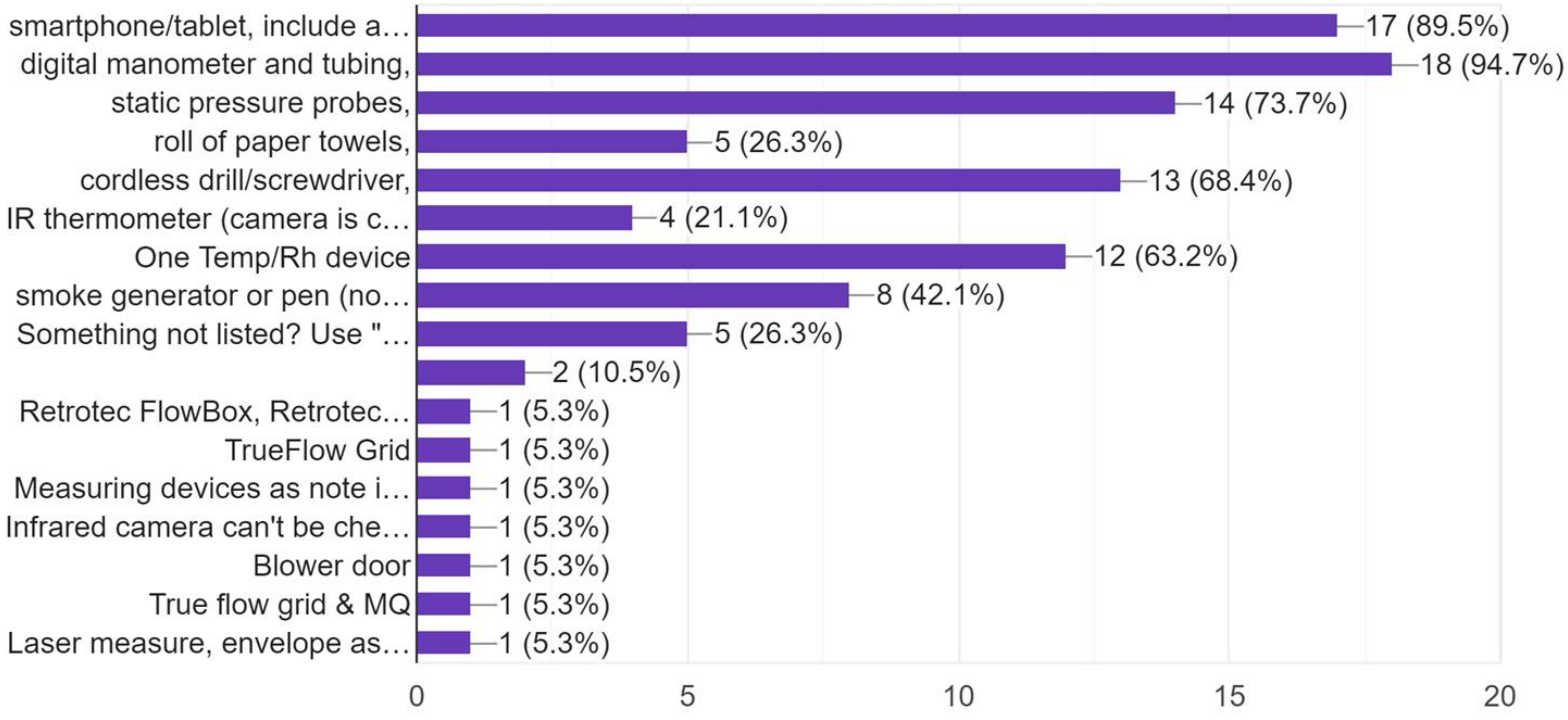
"As I turn on bath fans, I'll read flow with the flowbox (which can also contain all of my tools that I carry in!)……..Usually under 50 if they are crappy builder-grade models with bad duct runs and terminations. But if we assume 200 cfm for a dryer and add our bath fan measurements, we can get a rough idea of what flow it takes to move the house pressure down, if it moves at all." – Sam Myers

"Record make/model of all equipment. Sketch duct layout with sizes. Evaluated duct system capacity." – Russ King

"…use redcalc to determine exterior wall insulation with ir thermometer…" – Rick Hall

Select any of the tools you would use during the assessment. Make sure your description above has details on how and where you would use these tools....tools that are included are a flashlight and ladder

19 responses



The List

Visual Assessment – And Occupant interview

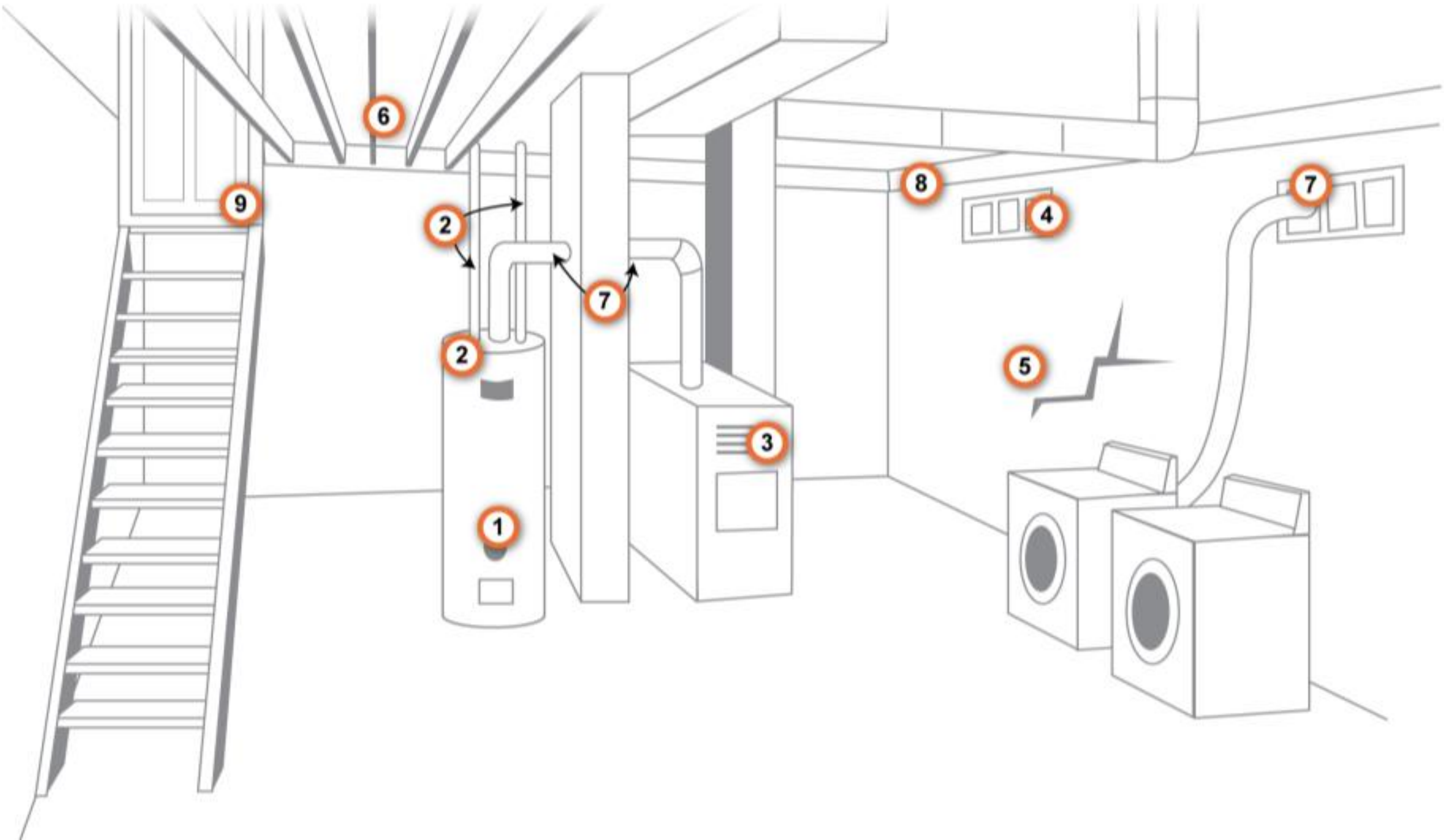
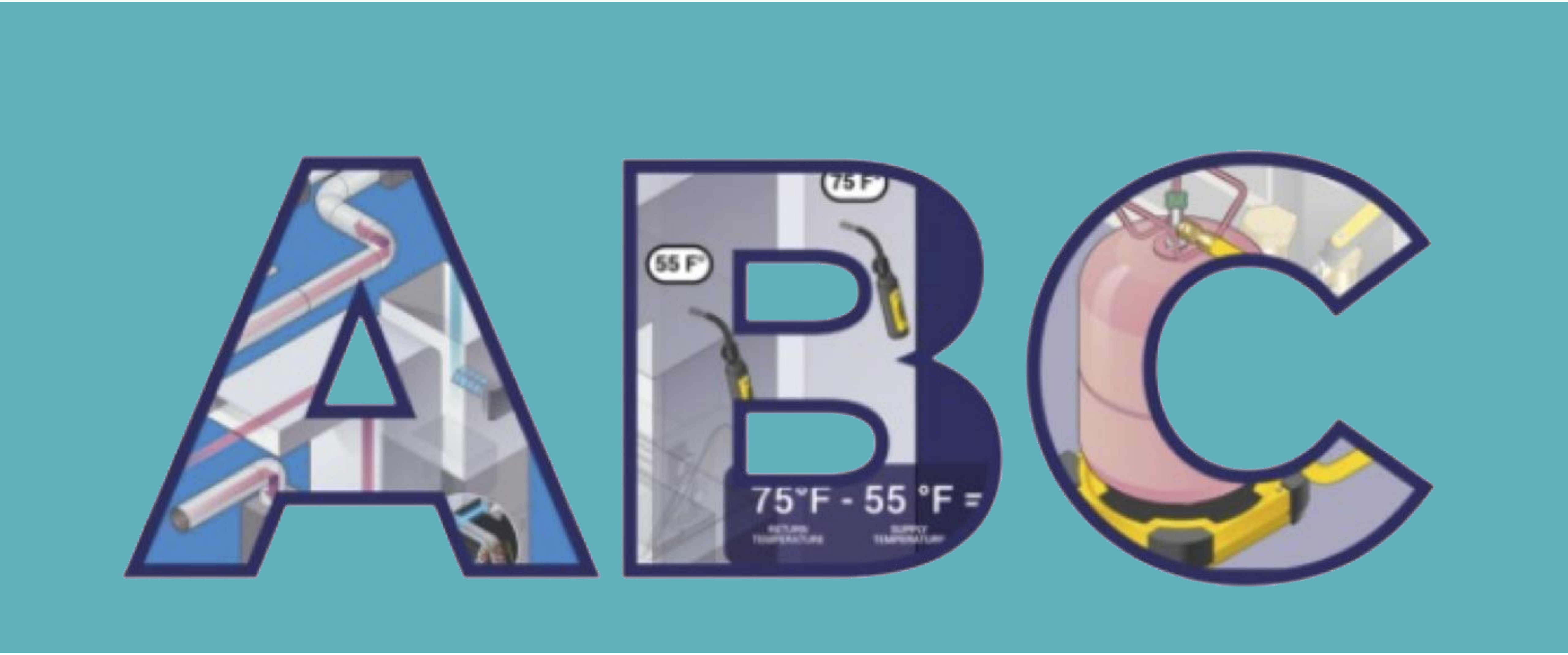


Image developed for the U.S. DOE WAP National Standardized Curriculum


ABC
75 F°
55 F°
75°F - 55 °F =

High Static Pressure with a PSC Motor

General External Static Pressure and Fan Relationship

PSC Motors

External Static Pressure IWC (Pa)	Air Handler Fan Flow Cubic Feet per Minute
0.69 (173)	1,350
0.62 (155)	1,400
0.55 (138)	1,450
0.47 (118)	1,500
0.39 (98)	1,550
0.31 (78)	1,600

If the static pressure is too high, the fan flow will drop.

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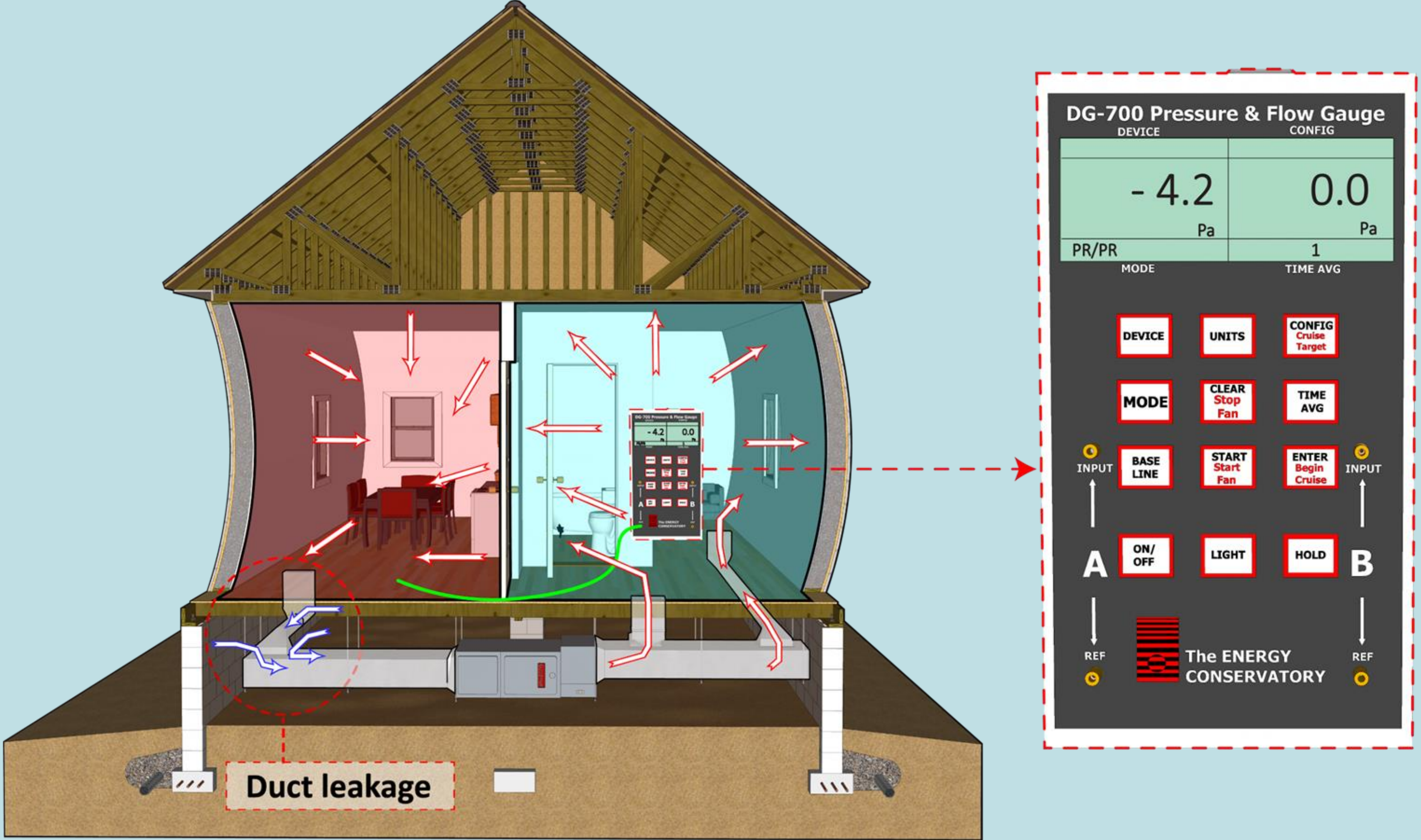
High Static Pressure with an ECM

With a high TESP, fan energy goes up

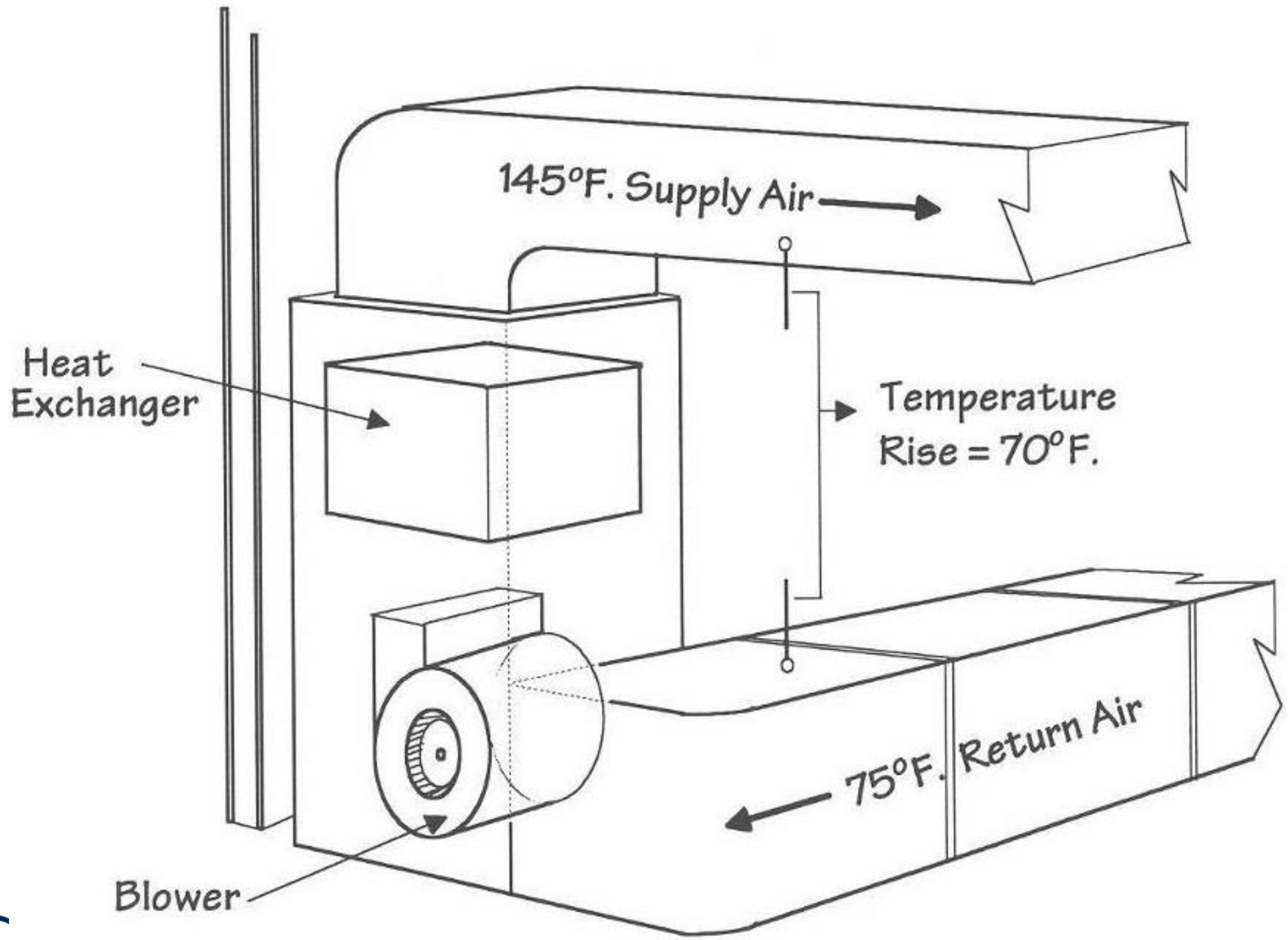
Table 10. Annual energy simulation results for both homes at baseline using the Austin contractor's designs

Home	Duct type	Blower type	Total Pressure (in. w.c.)	Airflow rate (CFM)	Cooling (kWh)	AHU Fans (kWh)	Total Electricity (kWh)	Heating (×10⁶ Btu)	Total Gas Consumption (×10⁶ 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


Duct leakage
DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
- 4.2
Pa
0.0
Pa
PR/PR
1
MODE
TIME AVG
DEVICE
UNITS
CONFIG Cruise Target
MODE
CLEAR Stop Fan
TIME AVG
INPUT
BASE LINE
START Start Fan
ENTER Begin Cruise
INPUT
A
ON/ OFF
LIGHT
HOLD
B
REF
The ENERGY CONSERVATORY
REF


CIRRUS™
Wind Indicator

Measuring Temperature Rise



The temperature rise for this example is 70˚:

145˚ supply side
-75˚ return side
70˚ temperature rise

measureQuick workflows – manual entry?

Guided Workflow Tutorials w/ Joe: Installation - Part 1

measureQuick
13.2K subscribers
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23
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Announcing measureQuick 2.5

Written by **Ben Reed**,
October 12, 2023

After 6 months of development and 3 months of beta testing, measureQuick 2.5 is finally released to the public.

measureQuick 2.5 is our most powerful and user-friendly version of measureQuick yet. With our new Guided Workflows, improved Bluetooth connectivity, ACCA VEO Certificates, and mQ Cloud updates, measureQuick 2.5 will help HVAC professionals improve their efficiency and profitability like never before.

New Features in mQ2.5

Guided Workflows

Guided Workflows are step-by-step instructions for completing common tasks, such as performing a maintenance check-up or installing a new system. Each Guided Workflow includes helpful pictures and instructions, as well as action items and next steps that must be completed before moving on.

Guided Workflows are a game-changer for HVAC professionals of all experience levels. They can help you complete tasks quickly and efficiently, reduce the risk of errors, and improve the quality of your work.


WHERE
are we going?
RDMPTN

What role a new hire, particularly one low on experience COULD take in your company…

- Assistant
- Zonal pressure tester
- Records all more complex tests
- Performs all qualitative diagnostics as part of install/service
- TESP specialist
- On the road to becoming an ARCS or TES

https://measurequick.com/solving-our-labor-endemic/

Introducing New Roles to Revitalize the HVAC Industry

measureQuick proposes two pivotal roles for the industry:

Tech-Efficiency Specialists (TES)

Advanced Residential Commissioning Specialists (ARCS).

These roles are designed to address the immediate needs of the market while complementing the current workforce. Union or non-union workers, these professionals are desperately needed.

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Turning this into job descriptions

Tech-Efficiency Specialists (TES)

Could be an Auditor or HVAC Tech

TES experts are at the forefront of enhancing homeowners' heating and cooling experiences. They bridge the gap between homeowners and contractors, focusing on system efficiency and sustainability.

They advocate for energy-efficient solutions, playing a key role in transforming maintenance into an opportunity for system improvement and profitable installations.

Advanced Residential Commissioning Specialists (ARCS)

Most likely HVAC tech

ARCS ensure newly installed HVAC systems are finely tuned to design specifications. Their work is crucial in validating system performance and efficiency.

ARCS are responsible for duct leakage testing, precise evacuation, airflow adjustment, and accurately setting the refrigerant charge. They ensure peak system efficiency, contributing significantly to system longevity and reliability.

What Is BetterHVAC?

The BetterHVAC Movement represents a groundbreaking initiative, propelling the residential HVAC industry towards a future of excellence and innovation. It calls upon professionals to rise above current standards and actively shape the industry’s future.

Threats & Topics

- ***Misunderstanding of Air flow & static pressure are the largest threats to better HVAC outcomes***, followed by snake-oil sales tactics

- Defining & promoting BetterHVAC practices was the most voted for topic, followed by curating better homeowner education, and attracting the younger generation

- The group believes we should collaborate with other orgs to improve trade school/training curriculum and produce better field research

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Let’s vote!!!

Would you add anything else to this list?

Would you re-order this list?

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Call to action!

Will you be adding any new low-cost diagnostics to your regular process (if you don't do them already)?

If you're a lead, will you add this into your training/mentoring curriculum (if not already there)?

Will you read Jim's article on changing and improving our workforce?

Break

15 min

Electric Panel Assessments

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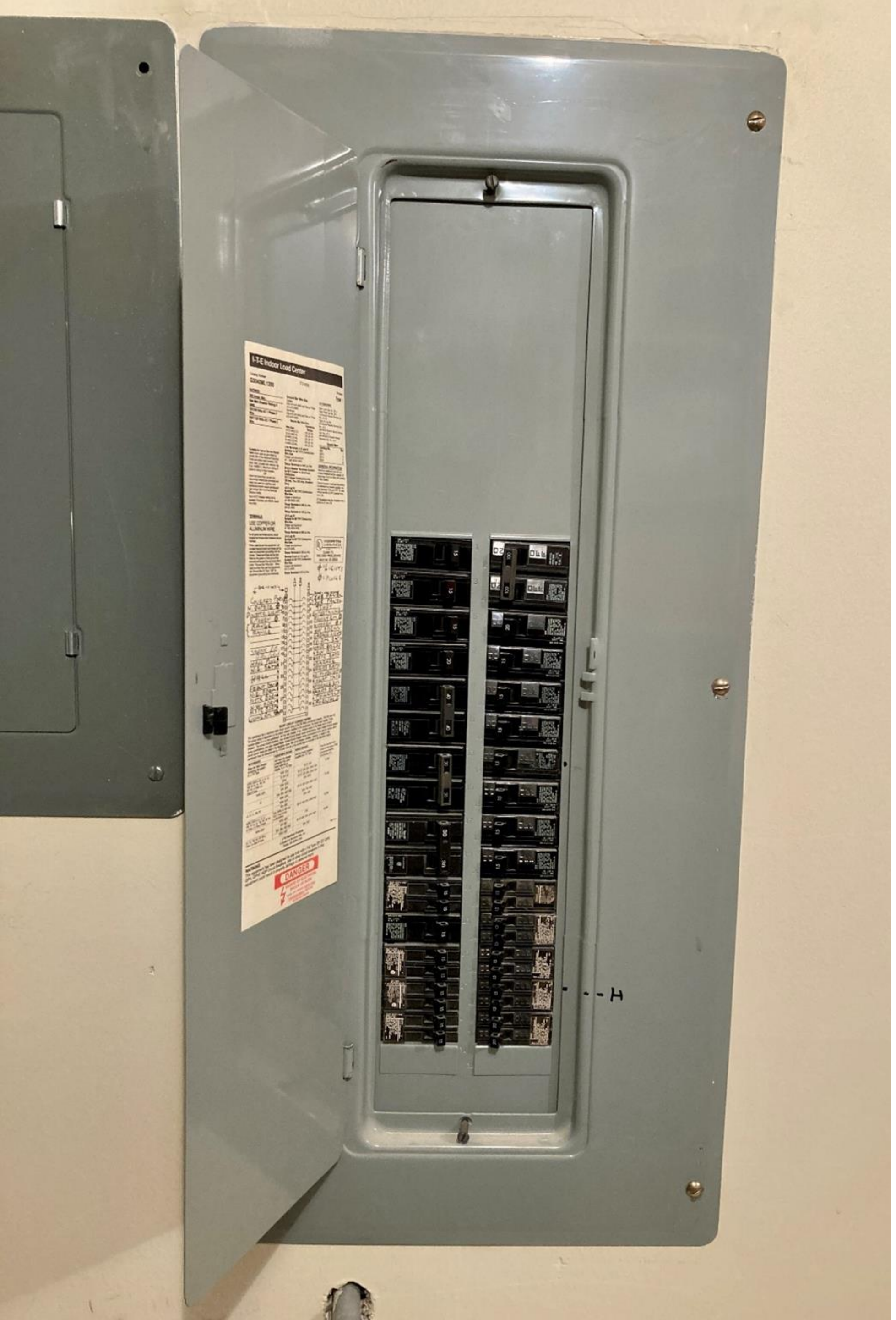


What are electrical panels?

- Electrical panels are also known as:
  - Breaker boxes
  - Distribution boards
- Divide incoming power from the utility into a number of circuits that feed power to the building's electrical appliances, such as lighting, outlets, and heating and cooling.

What role do they play in switching from fossil fuel to electric heat pump heating?

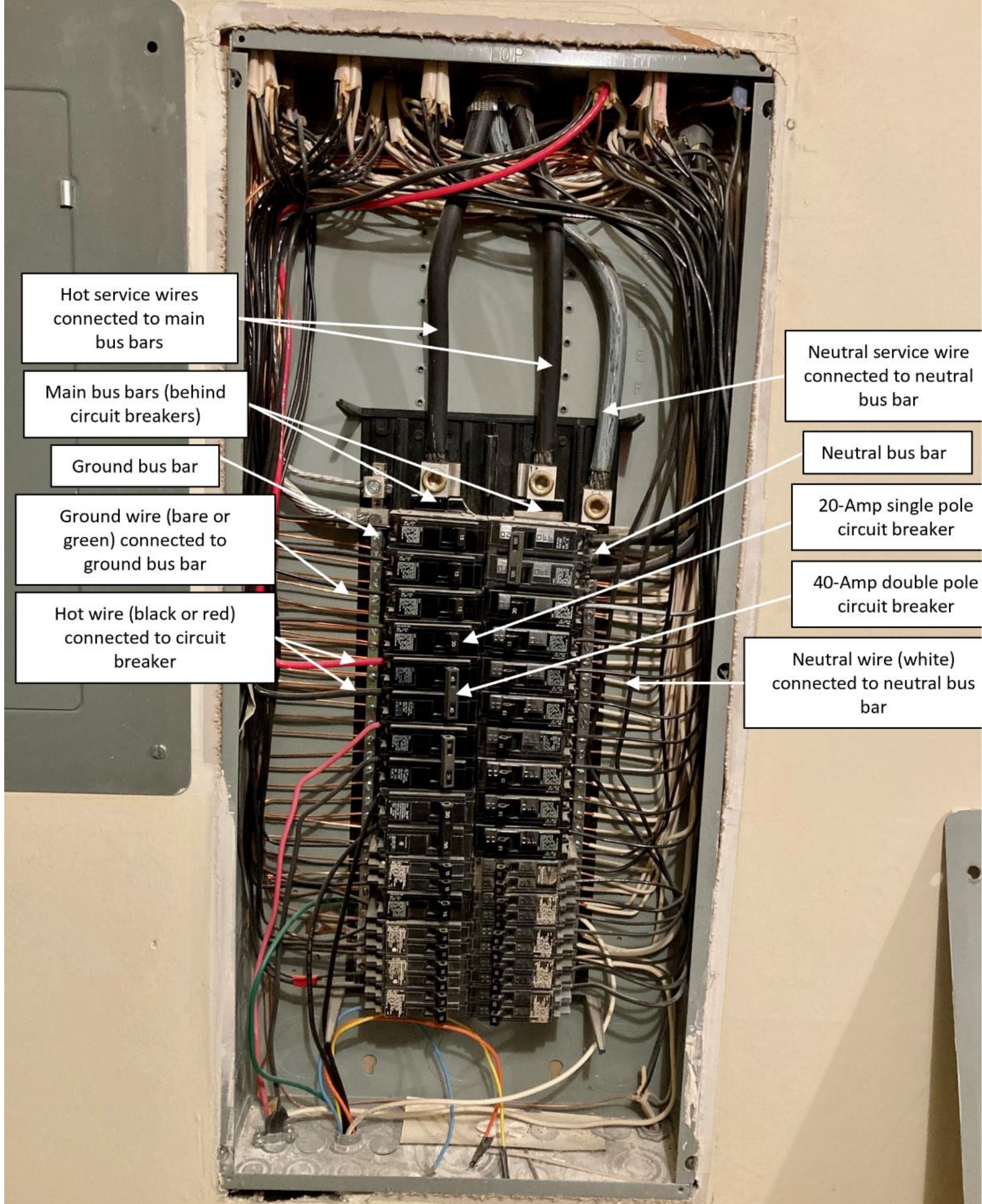
- When switching heating systems from fossil furnaces to heat pumps, it is recommended that a thorough electrical panel assessment be conducted.
  - Evaluate the existing panel condition and size, a whole house electrical load calculation including the consideration of any new or future electric loads and a determination of adequate physical space within the panel.
- This will help determine if any panel or service upgrades are needed, including whether a subpanel may be beneficial for the new heat pump

How to determine a home's electrical panel size

- The size of the home's electrical panel can be determined by checking:
  - The amperage rating printed on the home's electrical meter, which is typically located outside the home
  - The amperage rating printed on the label of the home's main electrical panel
  - Capacity of the main breaker (shown to the left)

What are the components in a typical electrical panel?

- Most residential electrical panels consist of typical components:
  - Hot and neutral service wires
  - Main bus bars
  - Neutral and ground bus bars
  - Circuit breakers
  - Hot, neutral, and ground wires



Adding circuits for new appliances

- To understand your electrical load and service capacity needs when adding circuits for new appliances, perform **a load calculation**
  - A load calculation sums the amperage of all the appliances in the home and then adds the new load of the heat pump to determine if the total amperage is less than the rating of the main breaker
- To calculate the electrical load per National Electrical Code (NEC) Article 220.82, follow the steps on the next slides
- First a key term to define:
  - **Volt-Ampere (VA)** - One VA is equal to one watt, but it describes apparent power, not real power. VA is used for an assumption of power that could be drawn instead of a measure of actual power drawn.

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Performing Load Calculations

1. General Electrical Load Requirements
    a. Take the area of the home, in square feet, and multiply the value by a general load assumption of 3 volt-amperes (VA) per square foot for lighting and general use receptacles.
    b. Count the number of small appliance circuits in your home, which may include a kitchen countertop where a toaster and/or a blender may be plugged in, entertainment centers, or home offices. If your electrical panel is well labeled, you can count the number of breakers that serve those areas. Otherwise, count the number of areas in your home that service these types of appliances. For example, if your home has one kitchen, an entertainment area where a TV, internet modem, and gaming console is plugged in, a home office, and 2 bathrooms, that would be five small appliance circuits.
    c. Multiply the number of small appliance circuits by an assumption of 1,500 VA per circuit.
    d. The same 1,500 VA assumption will also be applied to the number of laundry circuits, which refers to each clothes washing machine in the home. Clothes dryers are included in the next section.

Performing Load Calculations

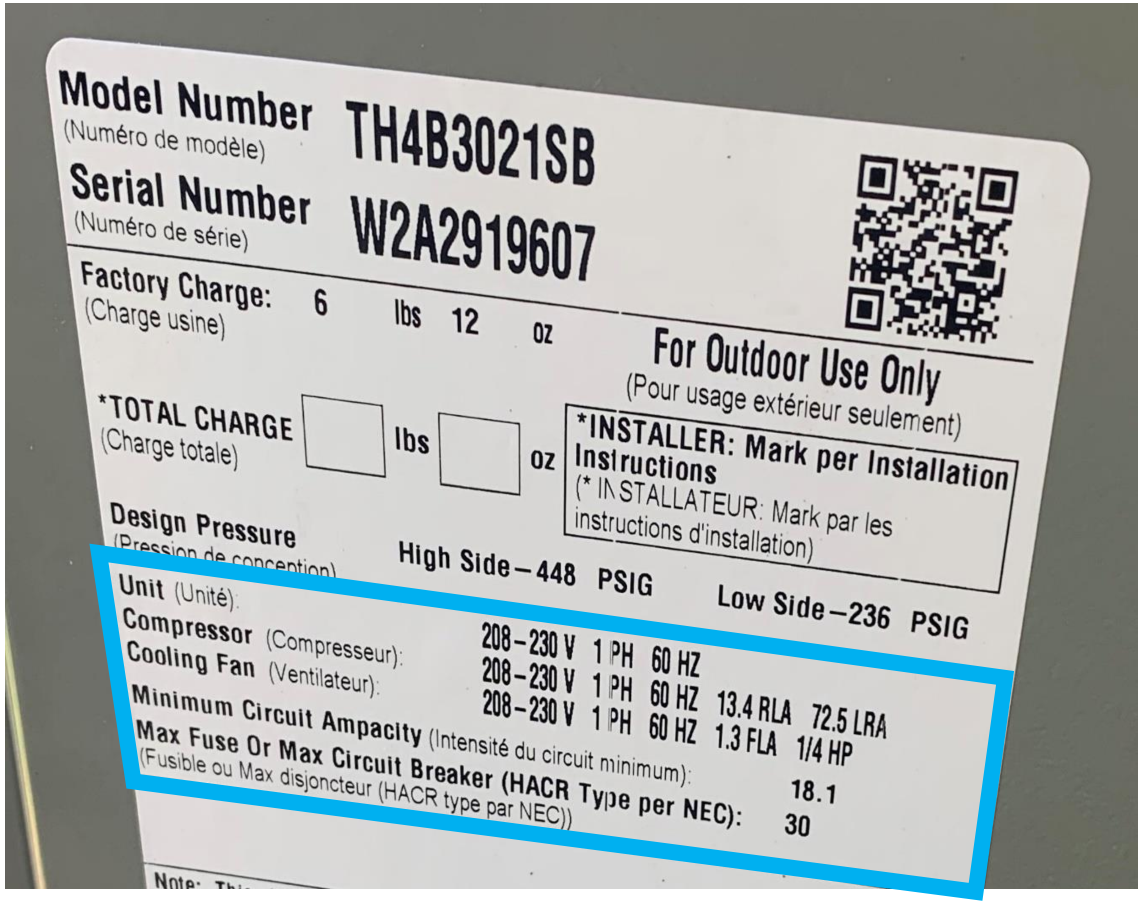
2. Appliance and Motor Loads
   a. Sum the nameplate wattage rating as a VA value of each appliance listed below:
      i. Appliances (like microwaves) that are fastened in place and/or permanently connected
      ii. Ranges, wall mounted ovens, counter mounted cooking units
      iii. Clothes dryers that are not connected to the laundry branch circuit
      iv. Once the lighting, small appliances, and motor loads are summed, apply the following demand factors:
      v. The first 10,000 VA are factored at 100%
      vi. The remaining VA are factored at 40%

Performing Load Calculations

3. Heating and Air Conditioning Loads
   a. Include only the largest from the following loads (i.e. only include the appliance from the list below with the highest power rating):
      i. 100% of the air conditioning nameplate wattage
      ii. 100% of the heat pump when used without supplemental electric heating
      iii. If using supplemental electric heating, 100% of the heat pump compressor and 65% of the supplement electrical heating
      iv. 65% of space heaters if using less than four separately controlled units
      v. 40% of space heaters if using four or more separately controlled units
      vi. 100% of the nameplate wattage rating of electric thermal storage and other heating systems

What does the heat pump need?

Recommended over Current Protection 208V/240V (Amperage Rating)	Copper Wire Size AWG based on NEC table 310-16 (75°C) UF type wire
15	14
20	14
25	12
30	10
40	8
50	6
60	4



20 Amps X 240 Volts = 4800 Watts / VA

Performing Load Calculations

3. Sum the loads and convert to amps
   a. Divide the total VA load by 240 volts, as that is the voltage supplied to the home. The resulting value is the total amps of the home which can be compared to the service capacity.

Load calculation example

- Calculate the electrical load for a 2,500 square foot single-family home using the following appliances:
  - 3 appliance circuits
  - 5,000W range
  - 1,000W dishwasher
  - 5,600W clothes dryer
  - 15,000W baseboard heating (resistance heaters)

- You can use the following assumptions:
  - 3 VA per square foot for lighting
  - 1,500 VA per appliance circuit
  - For general loads, assume the first 10,000 W at 100% demand factor and remainder at 40%.
  - For heating loads, assume 100% demand factor

Load calculation example

1. 2,500 square feet x 3 VA = 7,500 VA for lighting
2. 3 appliance circuits x 1,500 VA each = 4,500 VA
3. The general loads (range, dishwasher, and clothes dryer) can be added at their wattage rating as VA:
   a. 5,000 VA + 1,000 VA + 5,600 VA = 11,600 VA
4. Apply the demand factor to general loads:
   a. 10,000 VA x 100% = 10,000 VA
   b. 1,600 VA x 40% = 640 VA
5. Subtotal of general load is 10,640 VA
6. Add lighting and appliance circuits to the general load:
   a. 7,500 + 4,500 + 10,640 VA = 22,640 VA
7. Add in the heating load to the general load
   a. 22,640 VA + 15,000 VA = 37,640 VA
8. Divide total VA by 240V to get amps:
   a. 157A

Calculating new appliances

- Now that you've calculated the home's existing electrical load, you can perform a similar calculation to determine if the existing service capacity is sufficient to power a heat pump.
- This is important to ensure that the main breaker will not be tripped from drawing too much power when adding the new appliance.

Load calculation example

- Now assume you want to add a 4-ton heat pump unit with 40-amp breaker to replace the floorboard heaters and add cooling. Will your electrical load exceed the home's 200A service? Are you reducing or increasing the overall electrical load by adding the heat pump?

- Redo the calculation removing the floorboard heating and adding in the heat pump

Load calculation example

2500 SQFT home X 3VA	7500 VA lighting
3 Appliance circuits 1500VA each	4500 VA appliance
range 5000VA, dishwasher 1000VA, and dryer 5600VA	11,600 VA general load appliances
apply demand factor 8000VA@100% 3600VA@40%	demand adjusted general load 9440 VA
Add lighting and appliance circuits	21,440 VA
divide the total VA by 240 volts	89 Amps
Add the minimum circuit ampacity of the heat pump	20 Amps
Total panel Ampacity Needed	109 Amps

Adding the heat pump will not exceed the 200 Amp service

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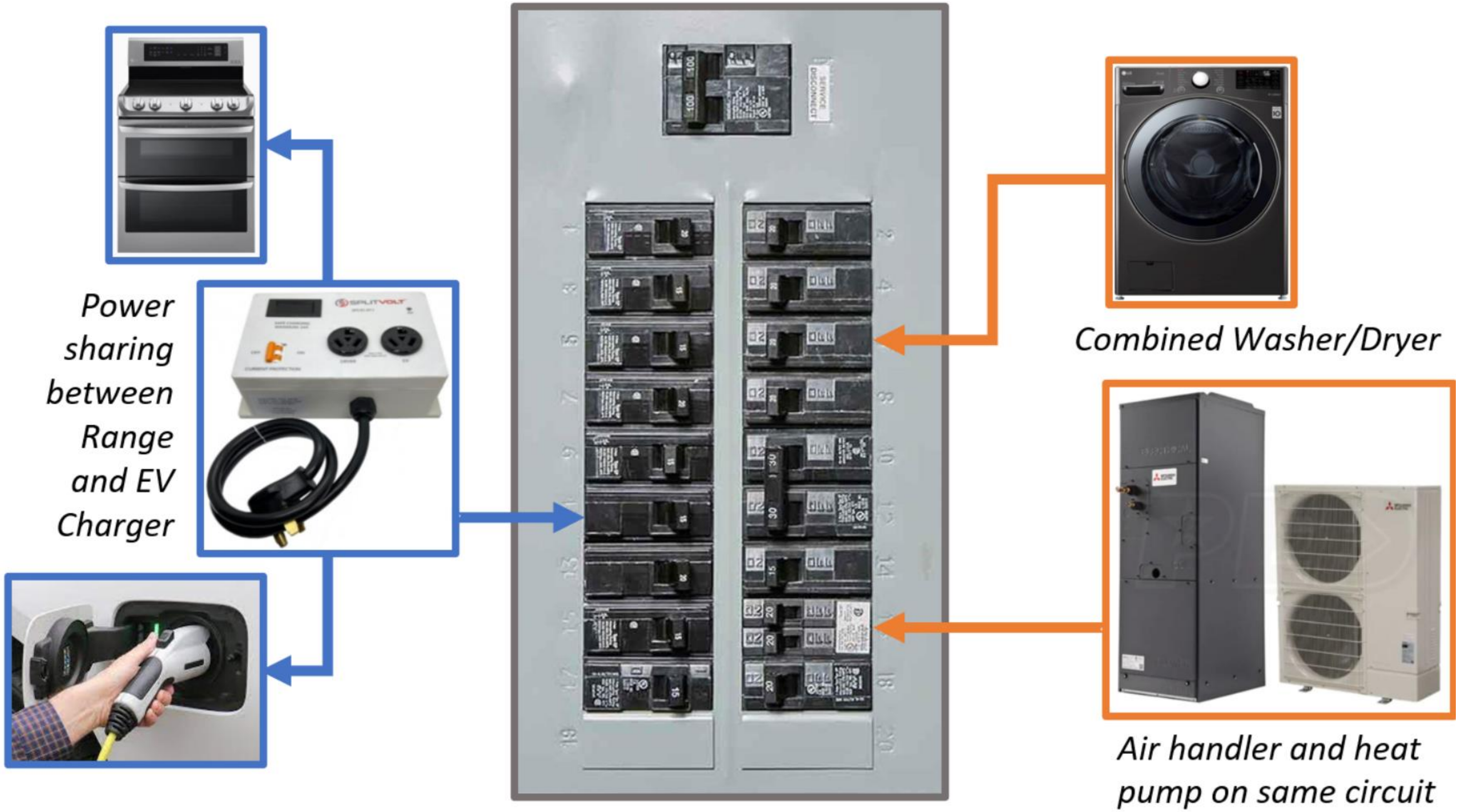
Load calculation example

2500 SQFT home X 3VA	7500 VA lighting
3 Appliance circuits 1500VA each	4500 VA appliance
range 5000VA, dishwasher 1000VA, and dryer 5600VA	11,600 VA general load appliances
apply demand factor 8000VA@100% 3600VA@40%	demand adjusted general load 9440 VA
Add lighting and appliance circuits	21,440 VA
divide the total VA by 240 volts	89 Amps
Add the minimum circuit ampacity of the heat pump	20 Amps
Air Handler with 5KW electric Resistance	14 Amps (20 Amps @ 65%)
Total panel Ampacity Needed	123 Amps

Adding the heat pump will not affect the homes 200 Amp service

Want to avoid the upgrade? Go on a diet!!



Share amperage between major appliances to better allocate circuit panel breaker capacity

Below is an example of how the main electrical panel in 2,000 square foot home might look, after the home is converted from

Want to avoid the upgrade? Go on a diet!!

Here's a 100 AMP diet for a moderate house

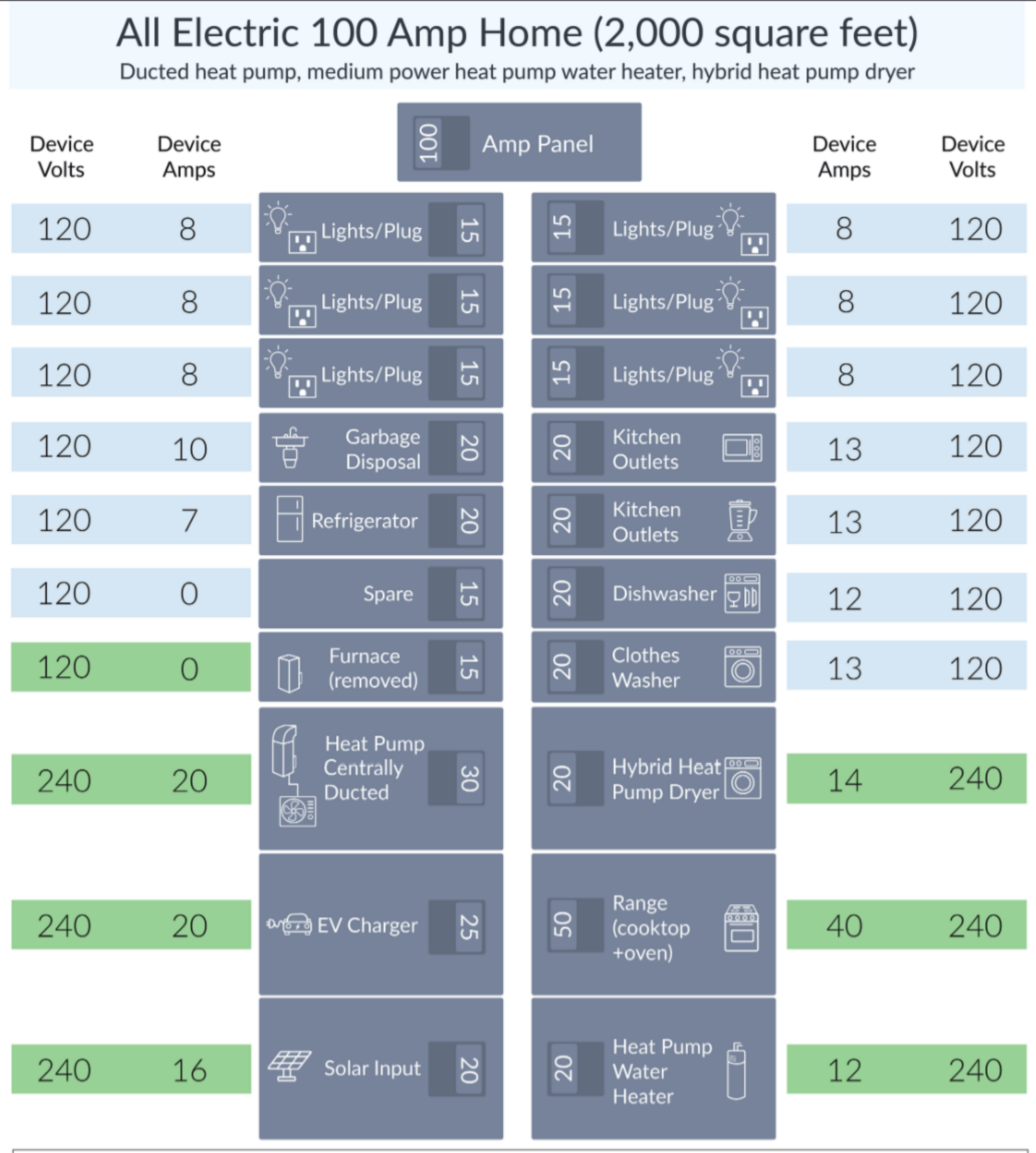
House square footage = 2000 | Total Counted Panel Amps = 96.7

Additional House Information

- 4 occupants
- EV charging up to 19 miles/hr
- Located in California climate zone 3 (SF Peninsula)
- Some insulation
- 38,000 Btuh heating and cooling
- 60-80 gallon heat pump water heater
- 4-burner induction or standard electric range
- 7.4 cu. foot hybrid heat pump dryer
- A 20-amp circuit will support a 3.8 kW inverter. (Many 3.8 kW inverters can support upt to a 5.8 kW solar array depending on inverter load ratio)

Diagram creation and design by: Josie Gaillard, Courtney Beyer, and Tom Kabat

Load calculations per the National Electrical Code Section 220.82(B) and 220.83(B)



Want to avoid the upgrade? Go on a diet!!

Her's a 100 AMP diet for a larger house!

House square feet = 3000

Total Counted Panel Amps = 97.2

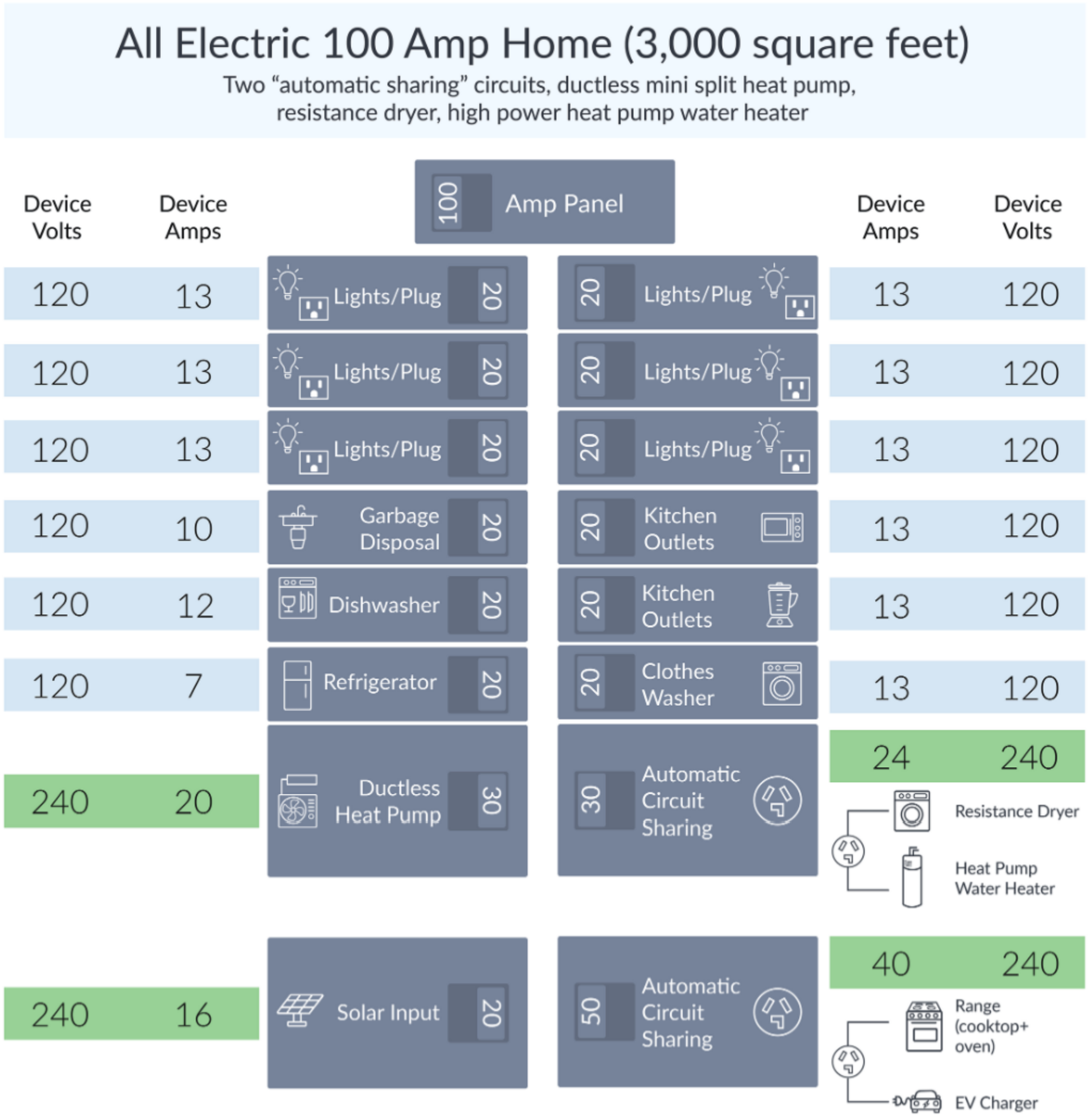
Additional House Information

- 4-6 occupants
- EV charging up to 38 miles/hr
- Located in California climate zone 3 (SF Peninsula)
- Some insulation
- 48,000 BTU heating and cooling
- 40-80 gallon heat pump water heater
- 4-burner induction or standard electric range
- 7.4 cu. foot standard resistance dryer
- A 20-amp circuit will support a 3.8 kW inverter. (Many 3.8 kW inverters can support up to a 5.8 kW solar array depending on inverter load ratio)

Diagram creation and design by: Josie Gaillard, Courtney Beyer, and Tom Kabat

Load calculations per the National Electrical Code Section 220.82(B) and 220.83(B)

Efficiently allocated 100-Amp electric service in 3,000 square foot home



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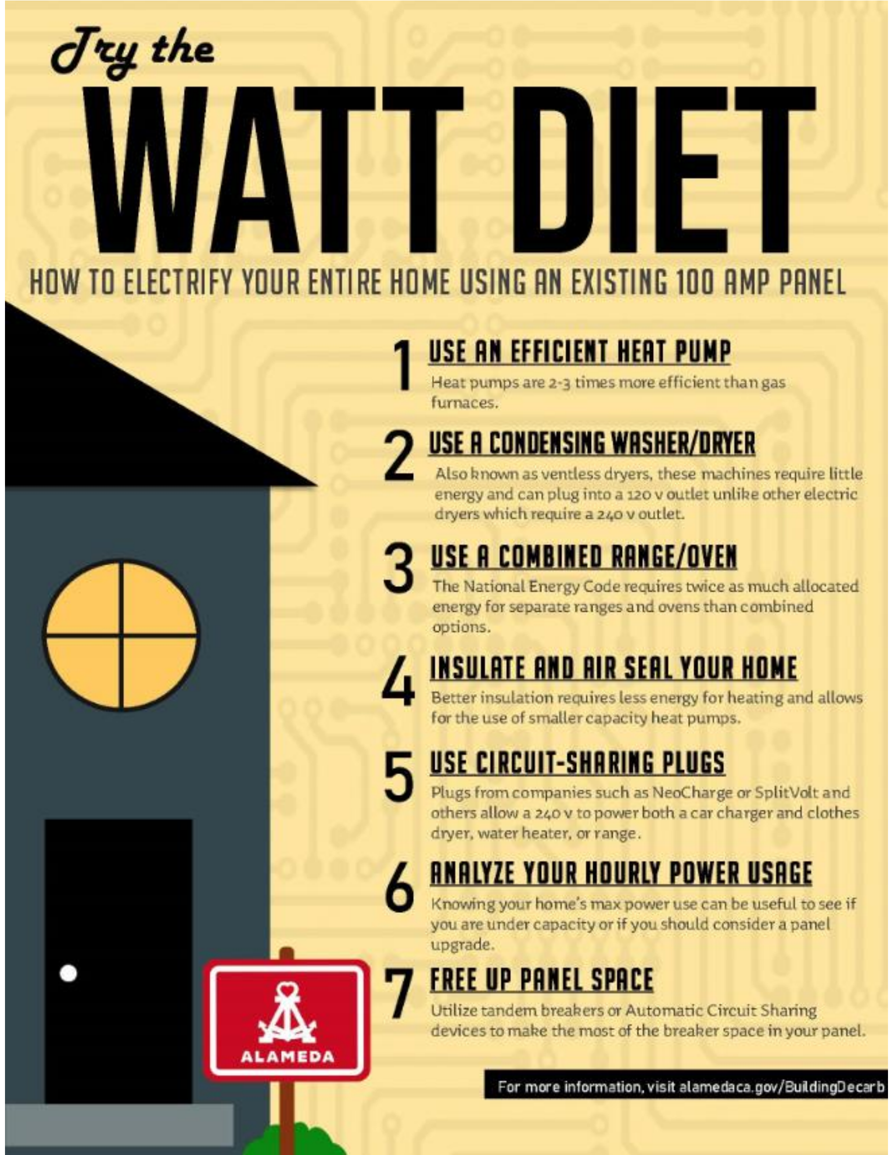
Hate math? There's an app (calculator) for that!

https://redwoodenergy.net/watt-diet-calculator/



THANK YOU

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Bonus Content

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HEAT PUMPS FOR AC REPLACEMENT

WHAT WE HOPE YOU'LL TAKE AWAY

- At the conclusion of this module, participants will:

- Identify key differences between heat pump and air conditioner installations, including controls and thermostat requirements

- Discuss factors that best predict heat pump performance when installed as an air conditioner replacement

- Understand the market and technologies for converting air conditioner replacements to heat pump installations

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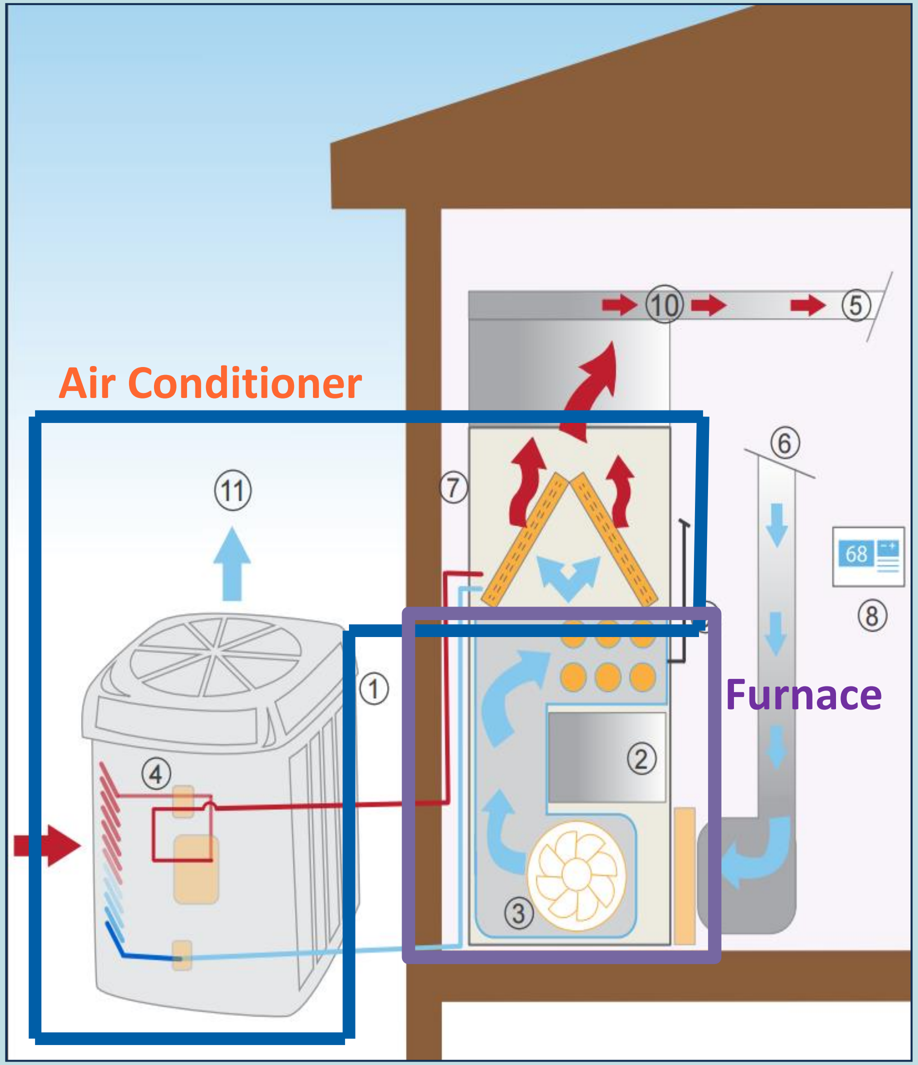
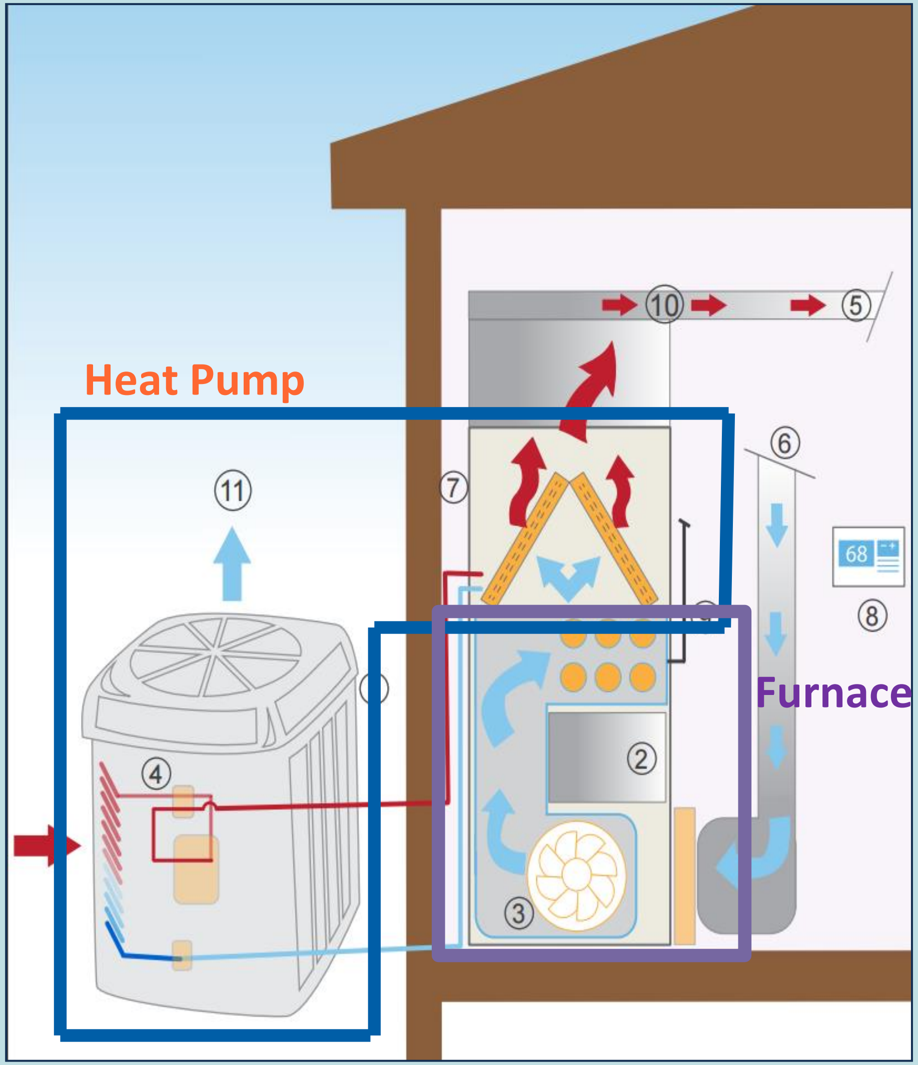
Heat Pumps as AC Replacements

What’s an AC replacement?

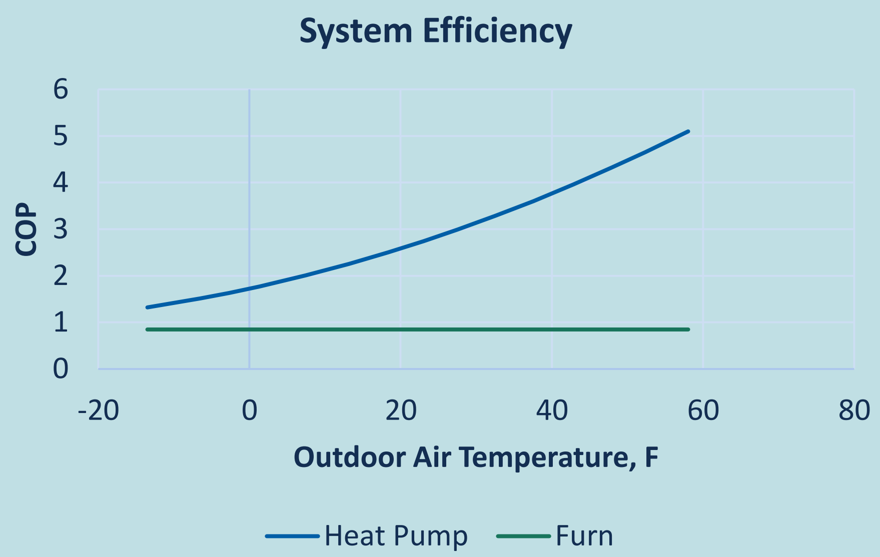
ANATOMY OF THE CENTRALLY DUCTED SYSTEM

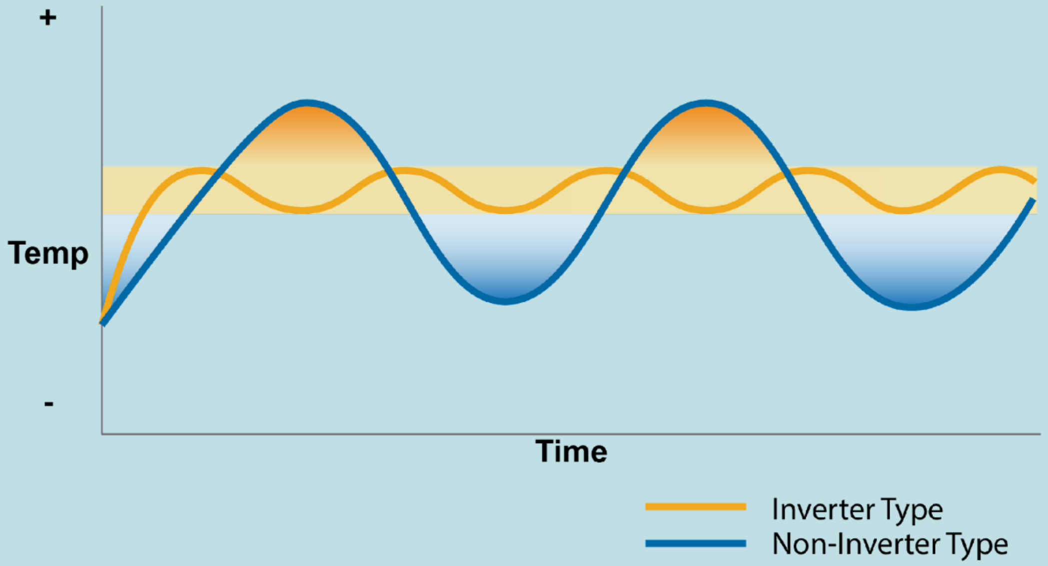




ASHP BENEFITS

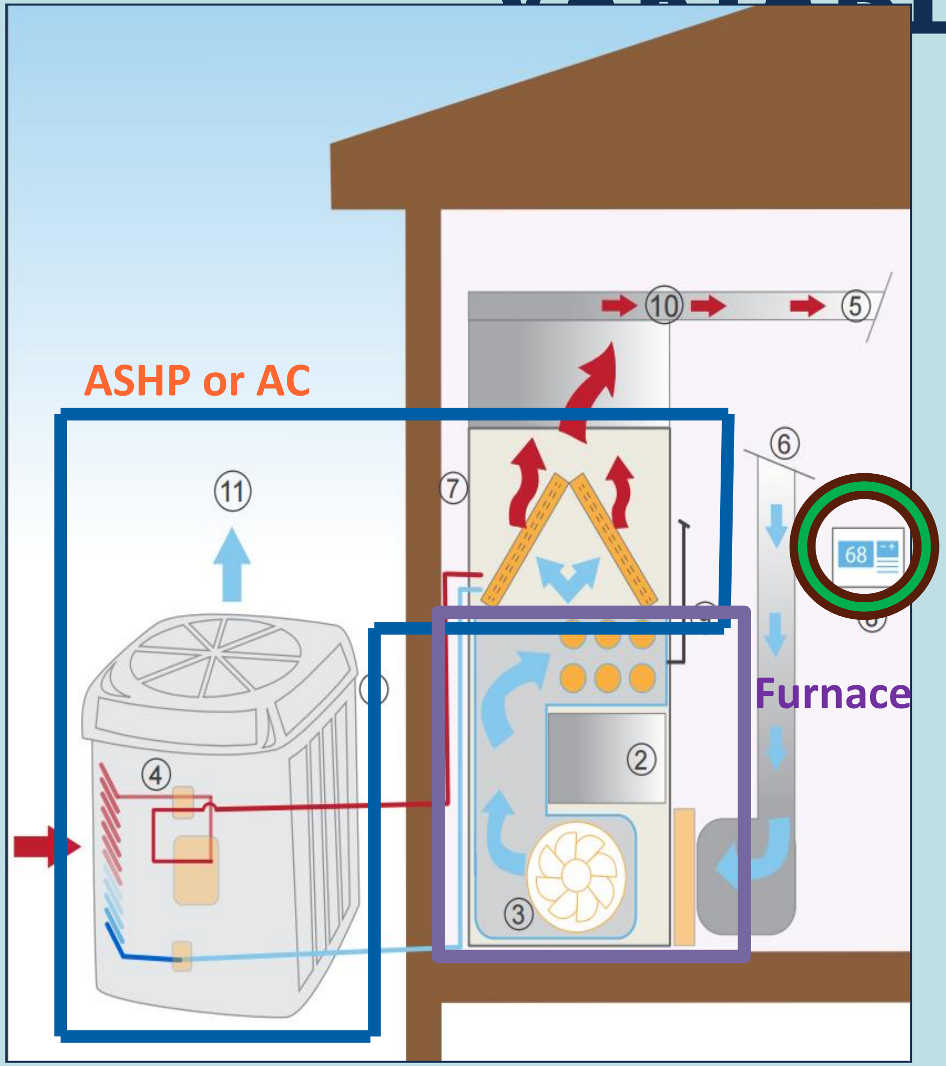
- Lifetime cost savings
  - HPs move heat, do not create heat
  - Efficiencies of 100% – 500%!
- Utility cost resiliency / fuel flexibility
  - Dual fuel operation allows for easy switching between heat sources
- Increased comfort
  - Inverter driven HPs better match output to actual loads
- Decarbonization and efficient electrification
  - 60% of Americans report concern about climate change (2022)





https://news.gallup.com/poll/1615/environment.aspx

NOW AVAILABLE: COIL-ONLY, CENTRALLY DUCTED VARIABLE SPEED HEAT PUMPS



- Dual fuel, centrally ducted air-source heat pumps (ASHPs) are a direct analogue to furnace-AC pairs
- Most ASHP products available have required simultaneous AC and furnace replacement
  - A limitation created due to rating standards and communicating system controls
- Coil-only ASHPs are a new product class that can install on pre-existing furnaces and air handlers
  - Coil-only ASHPs have different controls compared to matched furnace-ASHP pairs with communicating controls
  - May also be called "non-communicating" or "AC replacement" ASHPs and can be single or variable speed
- Thermostats/controls may be proprietary or third party and may need to be replaced to handle a VCHP that is dual-fuel

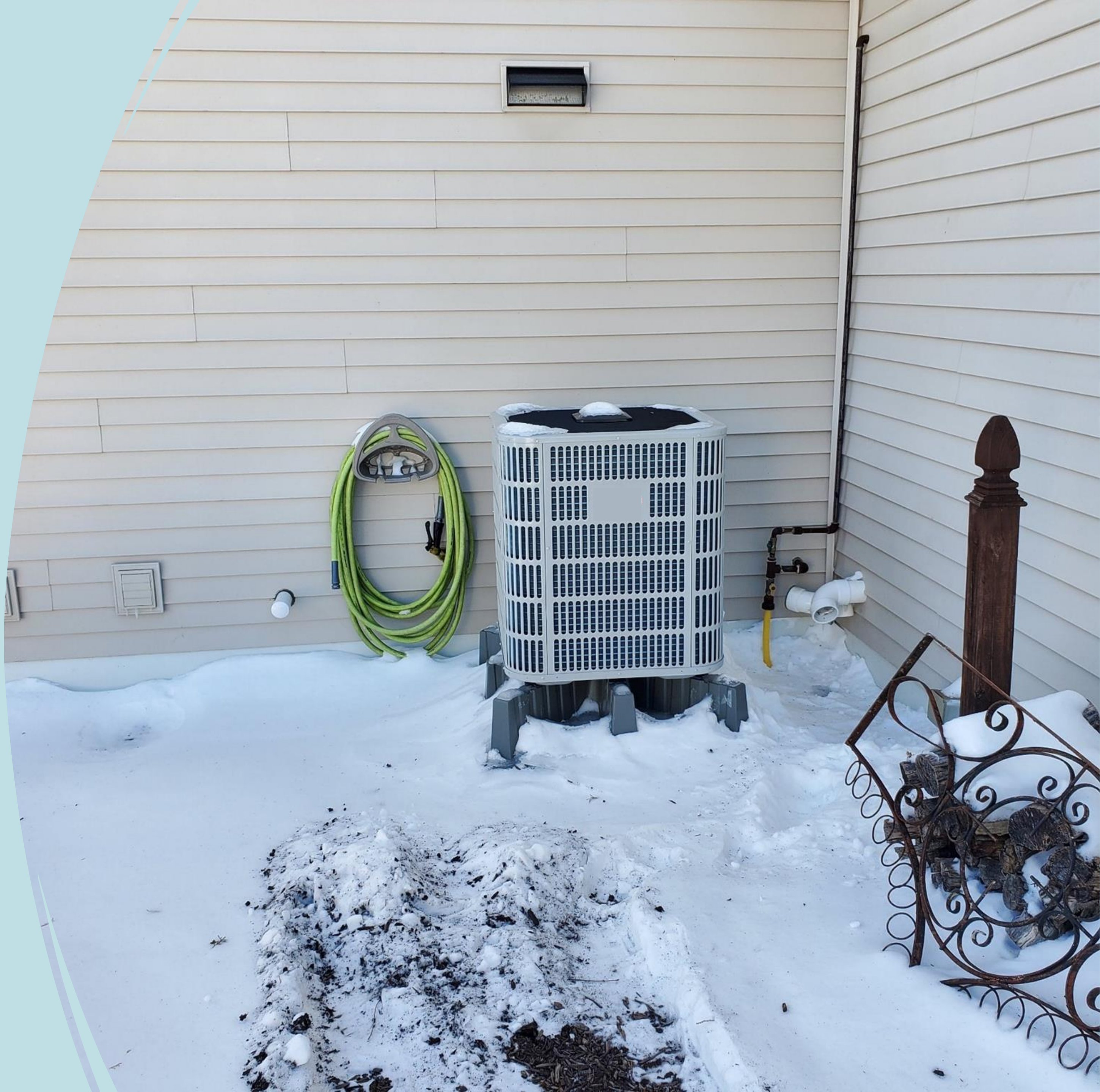
When it makes sense to keep the furnace

- Furnace is five years old or younger
  - These may have full matches available in AHRI
- Furnace is less than 10 years old
  - Still in the first half of the measure life
- Furnace air handler has had a motor replacement to an ECM
  - Regardless of AHRI match, these systems will have efficiency performance similar to a full system
- Furnace and Air Handler have been meticulously maintained and is under a maintenance/service contract, regardless of age

VSHPs as Drop-in AC Replacements

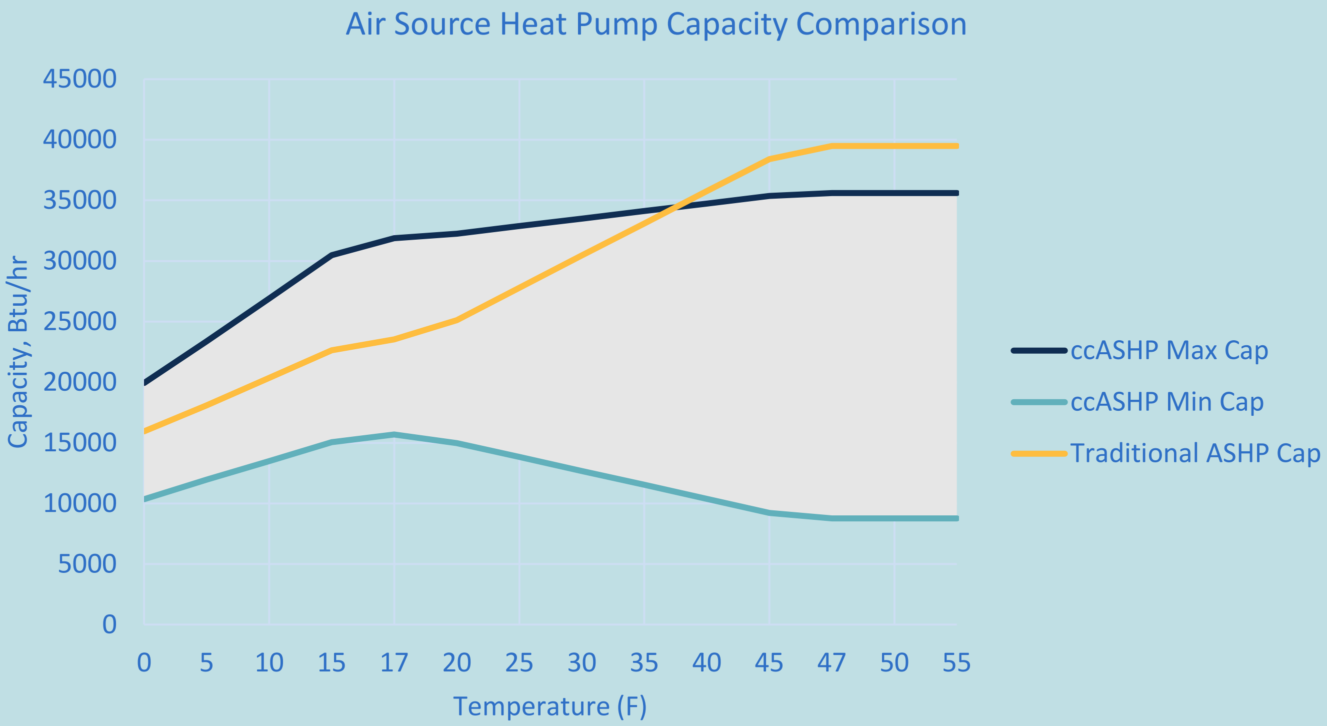
HEAT PUMPS VS. AIR CONDITIONERS: KEY DIFFERENCES

- HPs operate in both heating and cooling seasons, may impact siting to avoid ice build-up
- Sizing may be informed by cooling and/or heating loads
- Thermostat upgrades may be needed to control a HP



CHOOSE A WINTER FRIENDLY INSTALLATION LOCATION

SIZING VSHPs FOR HEATING



- VSHPs provide a lot more flexibility in sizing compared to single stage ACs
- Existing ACs and furnaces are often oversized
  - Load calculations are always recommended
- **SSHPs should be sized for cooling load**
- Coil-only VSHP models may have fewer offered condenser sizes
  - Manufacturers may offer only 3- and 5-ton condensers
  - Paired coil size and condenser dipswitch settings can scale down the VSHP output for mid-size applications

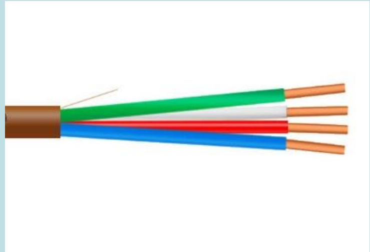
THERMOSTAT SELECTION & CONFIGURATION IS A CRITICAL DIFFERENCE BETWEEN HPS AND ACS

NOT ALL THERMOSTATS ARE DUAL FUEL COMPATIBLE

Not all dual fuel thermostats are VCHP compatible

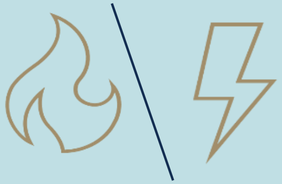
Selecting a heat pump compatible thermostat is NOT enough

DUAL FUEL THERMOSTAT FEATURES NEEDED:



4 or more wires or wireless

- Required to control the HP reversing valve to operate both heating and cooling modes
- Wireless thermostat models exist but cost more



Dual fuel controls software

- Configurable settings that distinguish between when to use HP for heating versus the supplemental furnace heating
- Some thermostats can control a HP but not a HP with an auxiliary heat source

Outdoor air temperature monitoring

- Can be a hardwired sensor, wireless sensor, or Wi-Fi connectivity to a local weather station
- Required to set a condenser lockout temperature, staging controls may be used if condenser lockout is not required

Multiple stage heating controls

- Optional, but lessen the importance of ASHP capacity limits
- Setpoint droops of 2-3°F are recommended, not time-based stages

Field Performance of VSHPs as AC Replacements

Early lessons to learn from!

FIELD STUDY APPROACH

- Engaged market actors to learn about VSHPs for AC replacements and build recruitment pathways
- Monitored 36 coil-only VSHPs and 3 SSHPs installed as AC replacements
  - 30 sites located throughout northern Illinois
  - 3 sites each in Denver, CO and Minneapolis, MN in Xcel's service area
- Gathered continuous operational performance data from late 2022 to summer 2023
- Surveyed participating homeowners about their experiences

Project funding was provided by ComEd and Xcel Energy

Heat Pump AHRI Ratings Matter

Indoor coil + Outdoor heat pump = Standalone SEER/HSPF Capacity

Rebate eligible options extremely limited

Furnace/Air handler + Indoor coil + Outdoor heat pump = Complete SEER/HSPF Capacity

Sometimes includes + UI

Indoor model # or style + Outdoor heat pump = SEER/HSPF Capacity

Indoor units can be: Ducted / Ductless / Mixed

COIL-ONLY MATCHING IN AHRI

Considerations for AC Replacement & keeping existing furnace:

Coil-only (Coil Mix-Match) ratings for AC replacement with heat pumps are derated to industry average air handler energy use.

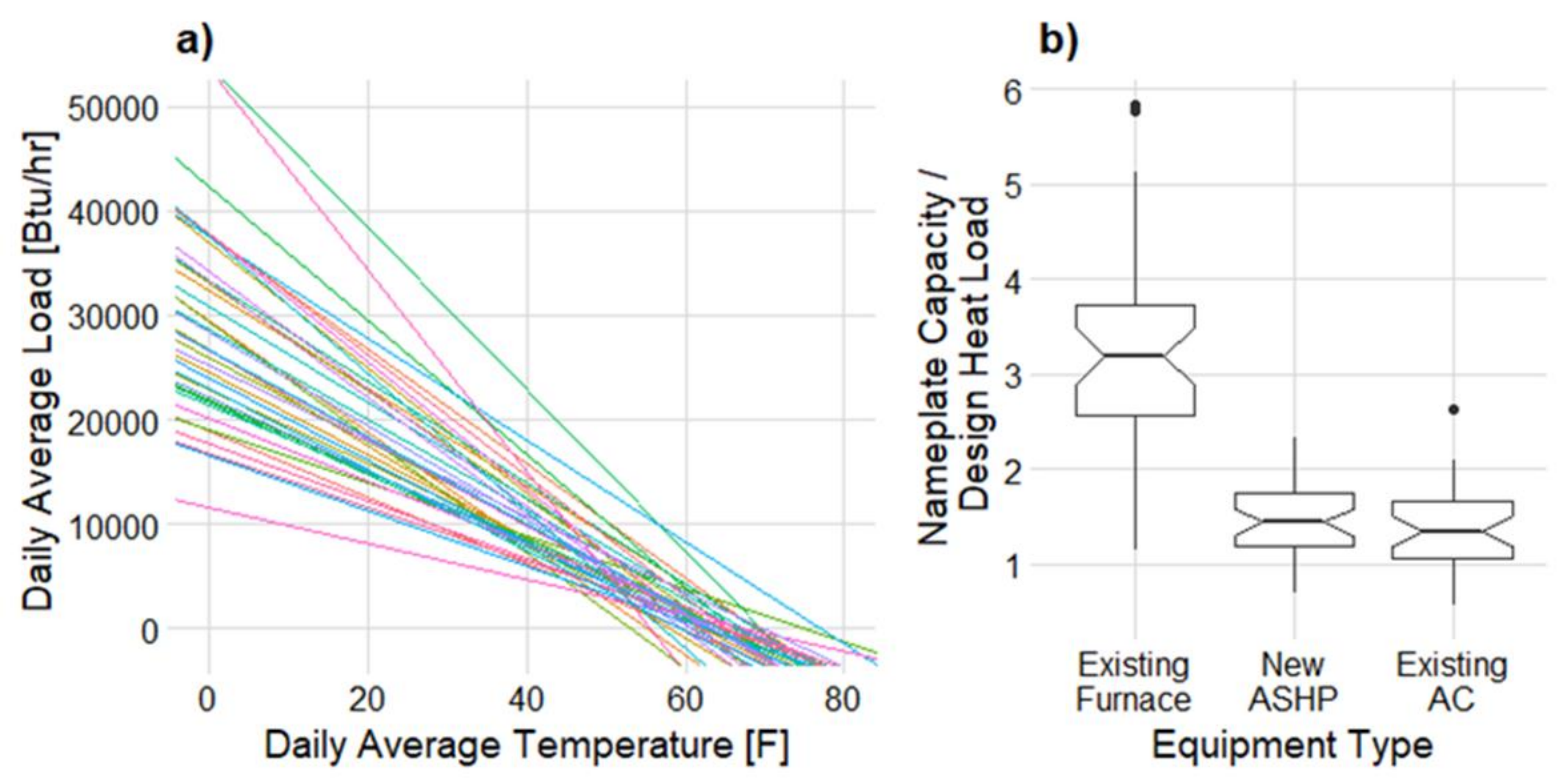
If furnace is 5 years old or younger, try searching for the full compressor, coil, furnace match to get best rated efficiency.

May only be available in reduced tonnages.

Use Quick Search Criteria if manufacturer is known.

Export Search Results and filter for matches without furnaces when manufacturer is not set.

SIZE MATTERS: EXISTING SYSTEMS ARE OVERSIZED



- Installers usually match new equipment size to pre-existing equipment sizes
- VSHPs sized the same as pre-existing ACs often have more heating capacity than expected from right-sized systems as existing equipment is oversized

SWITCHOVER SETTING RECOMMENDATIONS REQUIRE SEGMENTATION

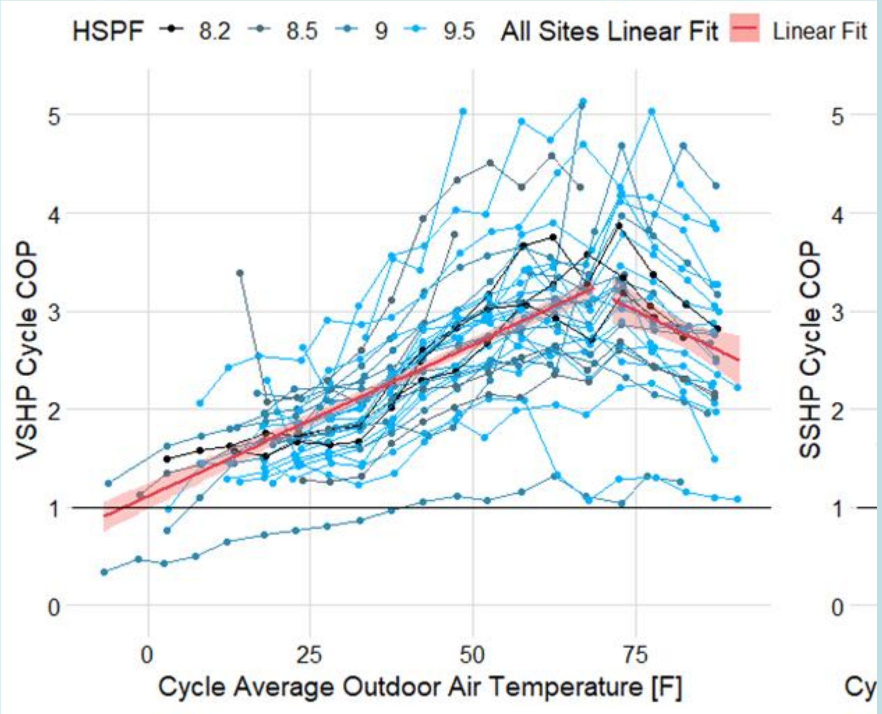
- Most VSHPs as ACs had capacity switchovers at or below 30°F
  - Economic switchover is usually above this for natural gas customers at current rates
  - Propane, ER, customers will usually save more with capacity switchovers

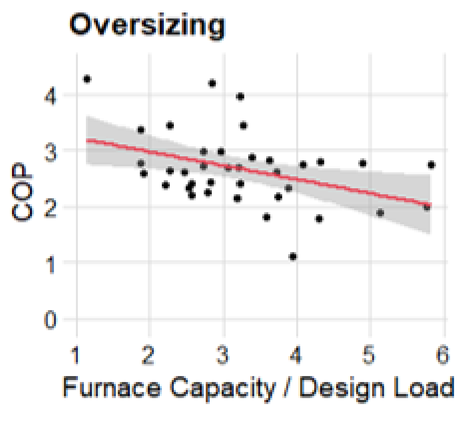
- Capacity switchover is strongly dependent on how oversized existing equipment is rather than size of ASHP
  - SSHPs will tend to have higher capacity switchovers compared to VSHPs regardless

- Staged heat controls reduce the risk of discomfort if switchover is set too close or below the capacity balance point
  - Recommend using setpoint droops of ~3°F rather than built-in algorithms or timer-based staging for most efficient results, then adjust switchover based on comfort

- Customers should be encouraged to revisit their switchover settings regularly

VSHP AS AC REPLACEMENT COPs VARIED SIGNIFICANTLY



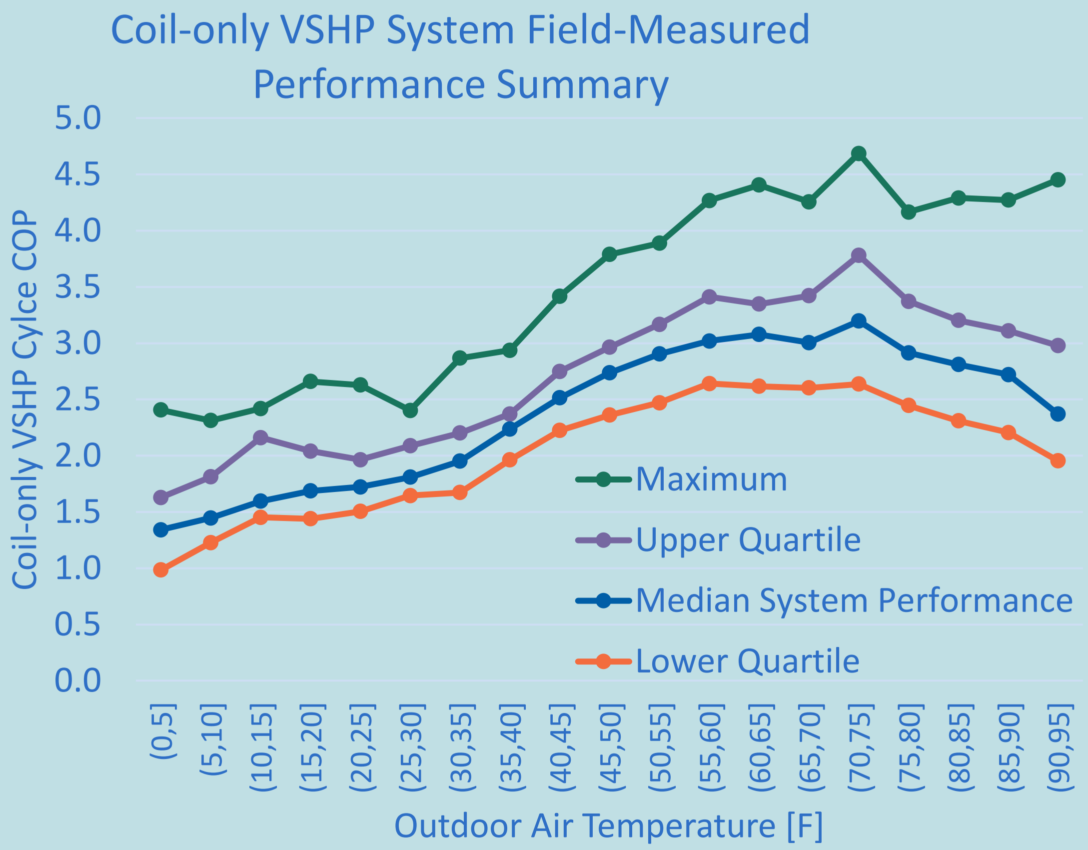


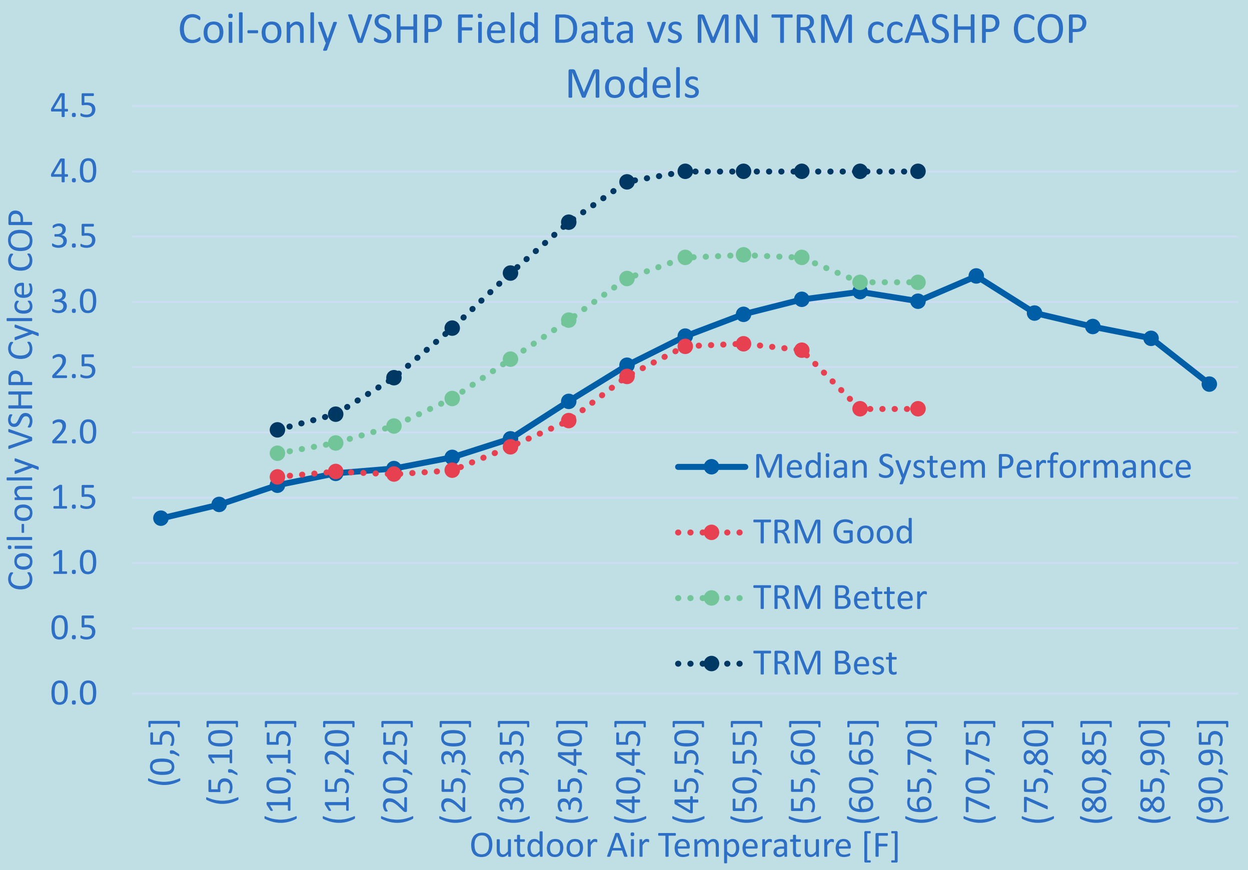
- HSPF ratings did NOT predict actual COP trends
- COPs averaged across sites are within lower range of previous VSHP field study results
- Data certainty below 20°F is significantly reduced due to less available data
- Oversizing is correlated with short cycling, especially in mild weather

MAJOR FINDING:

IMPROVING INSTALLATION QUALITY IN TERMS OF RIGHT-SIZING AND MAXIMIZING VSHP CYCLE RUNTIMES THROUGH THERMOSTAT SETTINGS ARE EXPECTED TO HAVE MORE IMPACT ON SAVINGS THAN PROMOTING HIGHER AHRI RATINGS FOR VSHPS AS AC REPLACEMENTS RIGHT NOW.

COIL-ONLY VSHP COPs LIKE "GOOD" COLD CLIMATE VSHPS





TRM data from Appendix G version 4.1

ccASHPs represent fully matched AHU/VSHP pairs

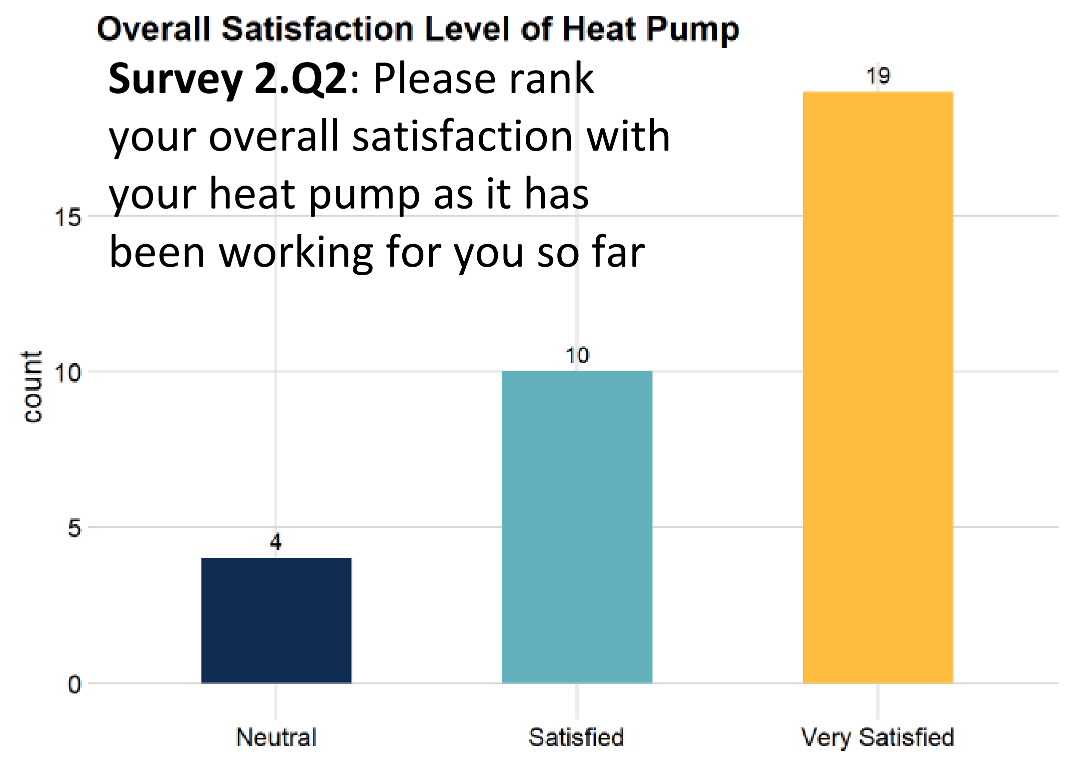
MAJOR FINDING:

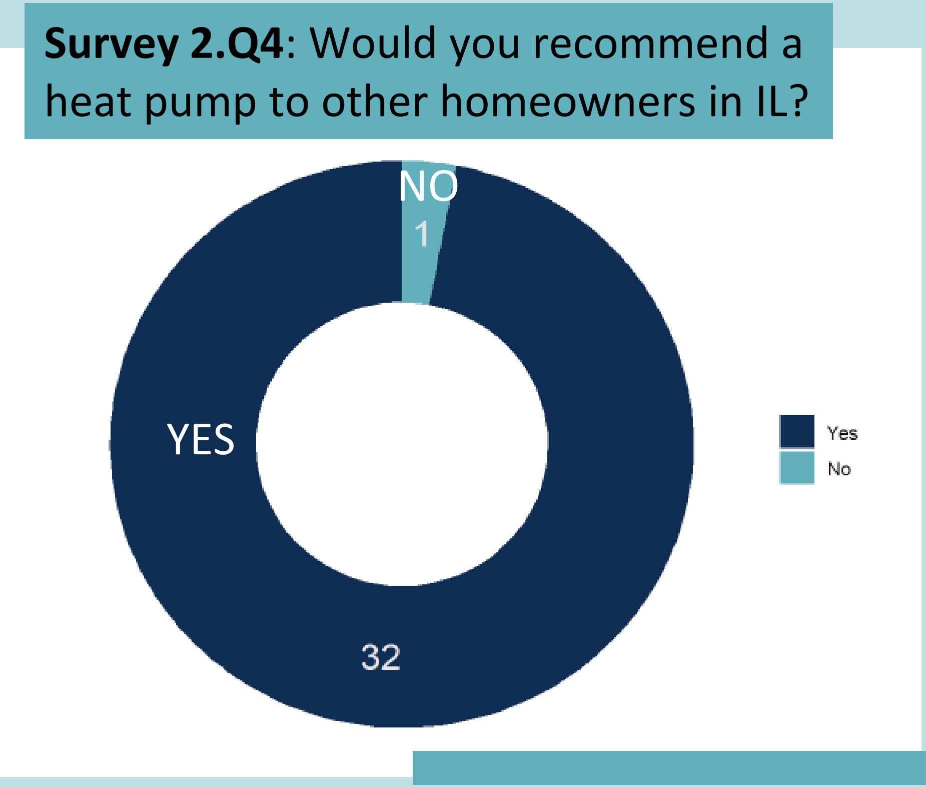
COIL-ONLY VSHPS HAVE GOOD PERFORMANCE AND THE BEST INSTALLATIONS CAN COMPETE WITH THE BEST COMMUNICATING VSHPS WHILE SAVING THOUSANDS IN FURNACE EQUIPMENT COSTS.

Customer Feedback

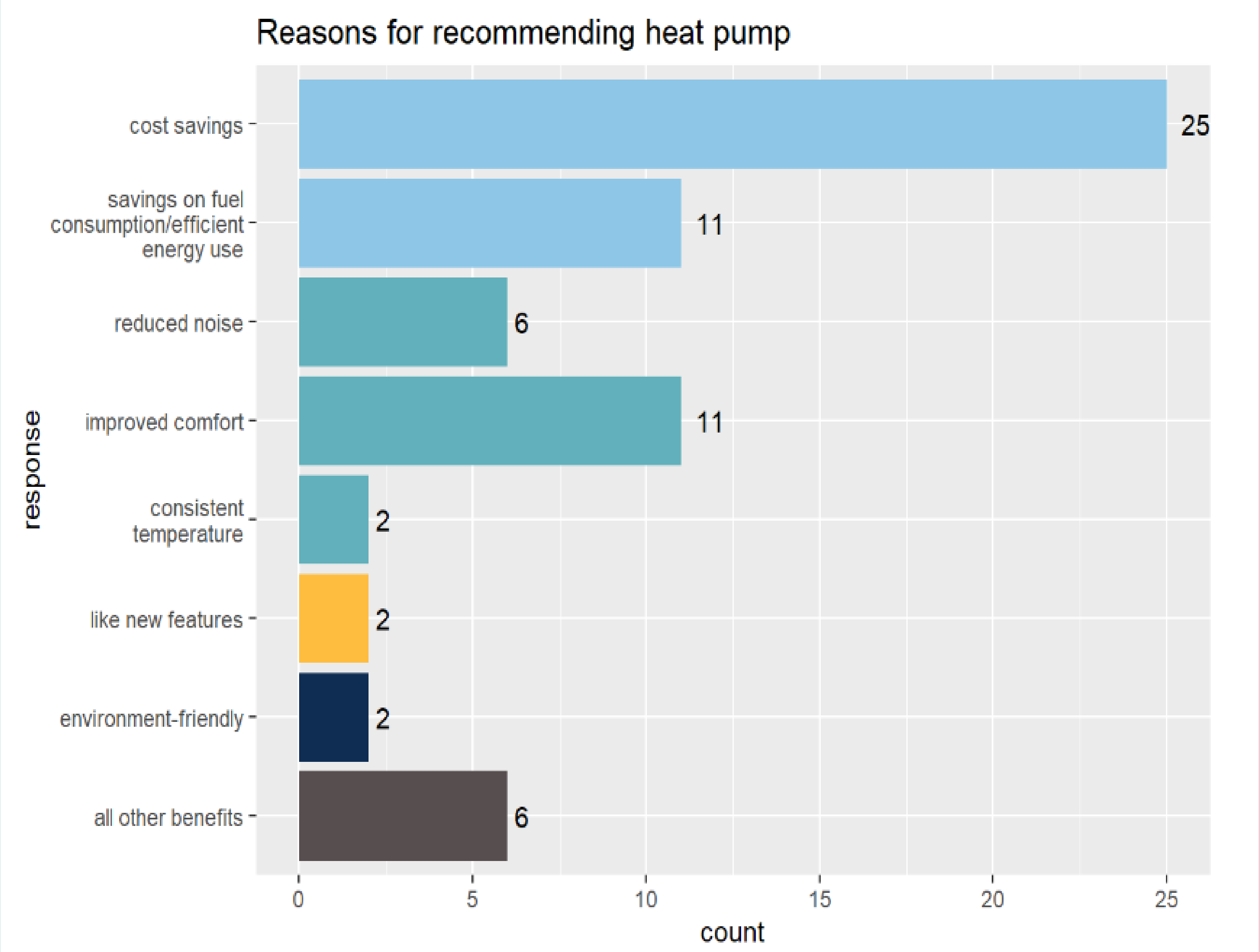
HOMEOWNER SENTIMENTS ARE POSITIVE AFTER HP INSTALLS

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





WHY WOULD HOMEOWNERS RECOMMEND VSHPs?



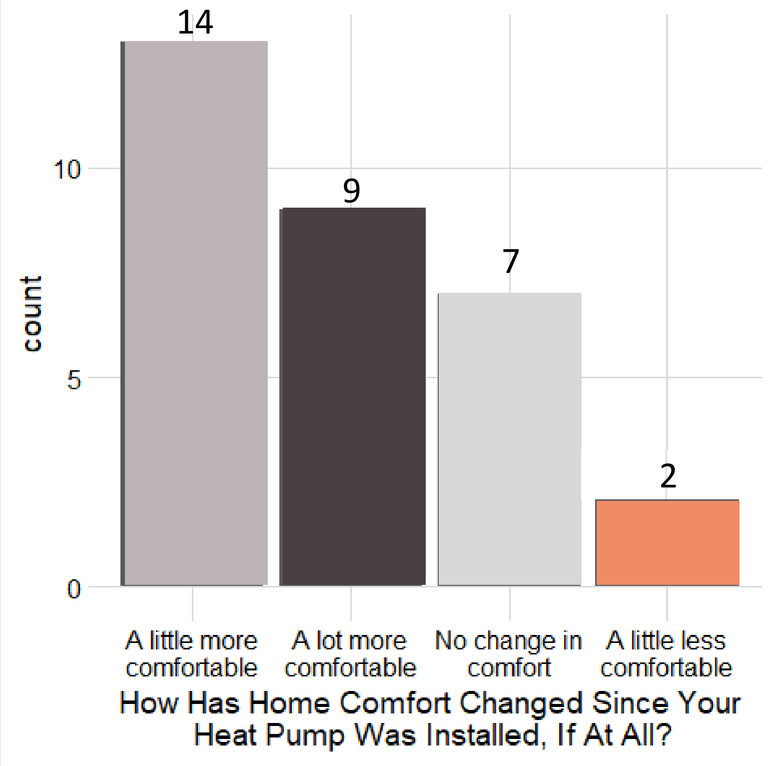
- 25 participants stated that they felt their VSHP **saved costs**
  - 11 participants mentioned savings on **energy/fuel**
- 11 participants mentioned **improvement in comfort**
- 6 said the HP **reduced noise**

VSHPs USUALLY DELIVERED IMPROVED COMFORT

Most Common Positive Sentiment Mentions:

Consistent temperatures

Better cooling



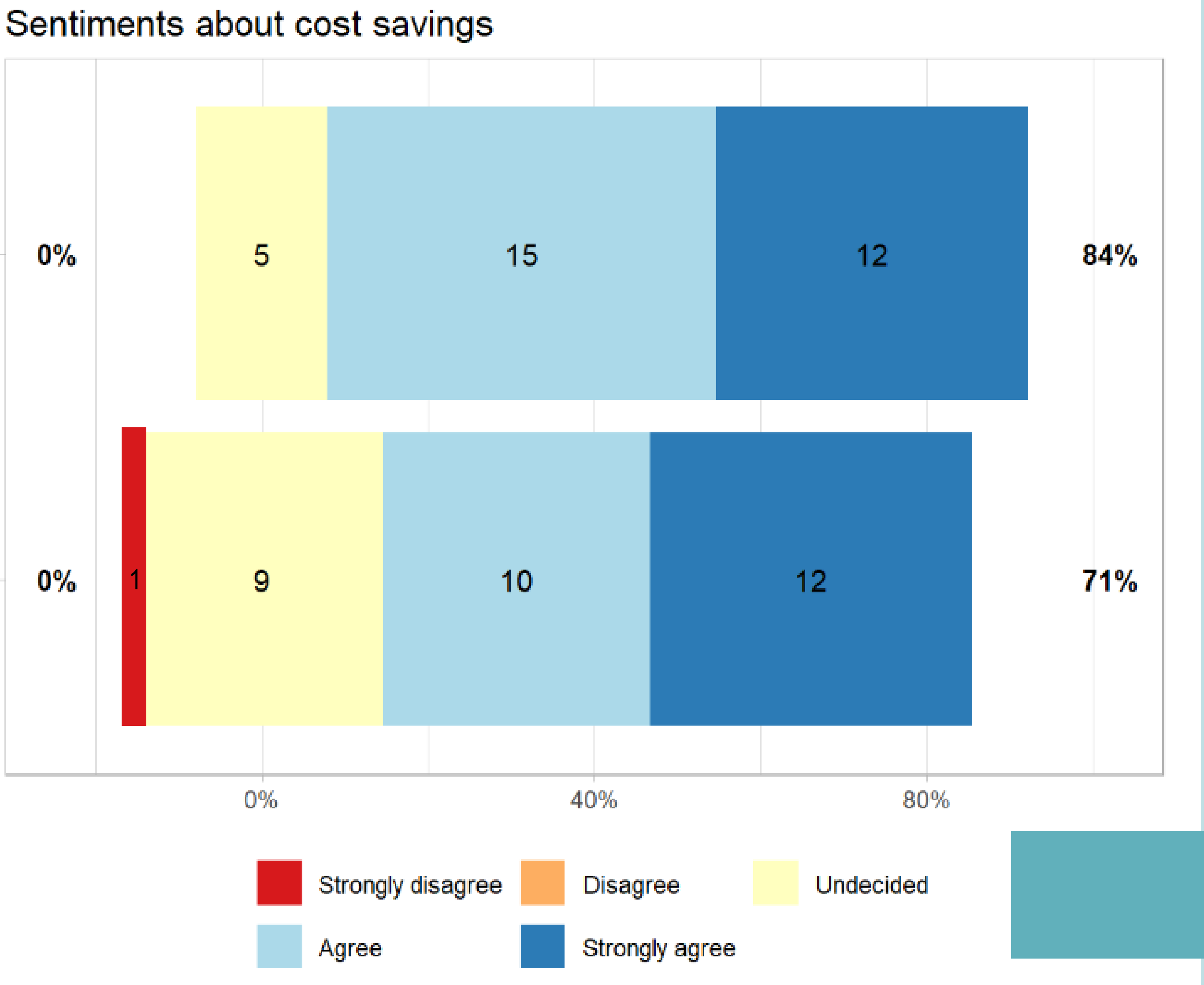
Comments from homeowners who felt **a lot more** comfortable:

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

HOMEOWNERS *GENERALLY* AGREE VSHPs ARE WORTH THE COST & SAVE MONEY

Overall, my heat pump was worth the installation cost

Overall, my heat pump has saved me money on my total heating and cooling costs

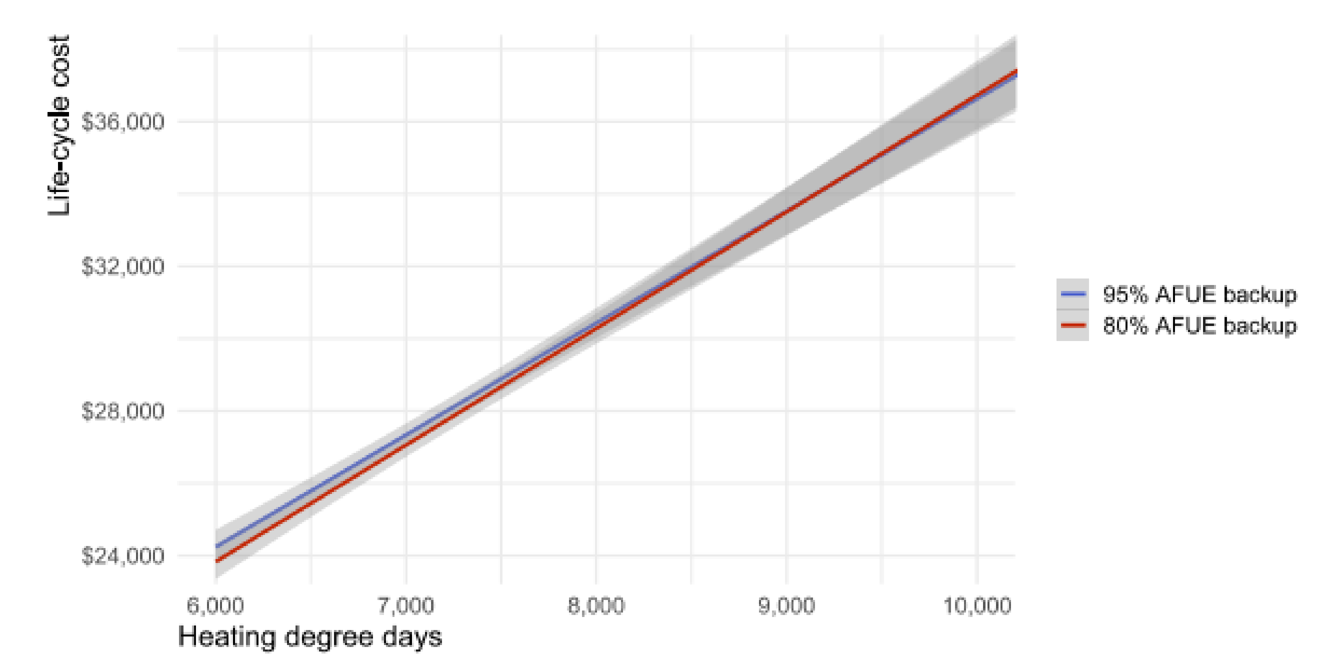


Single homeowner who felt they didn't save money overall believed it was because "the comfort is much greater"

Choosing the Right AC Replacement

AC REPLACEMENT CONSIDERATIONS

- What is the existing heating fuel type?
  - What are the rates and fuel costs?
- What is the furnace's usable lifetime? And performance specs?
- What is the customer looking for?
  - Comfort
  - Cost savings
  - Emissions reductions
  - Efficiency



OPTIONS FOR AC REPLACEMENT

Air Conditioner
- Air conditioner, any efficiency

Single/Two Stage HP
- Entry-level, single or two stage heat pumps (SSHPs)

Coil-only VSHP
- Coil-only variable speed heat pump

Cold Climate ASHP
- Cold climate, communicating variable speed heat pump

Better Performance

OPTIONS FOR AC REPLACEMENT

Air Conditioner

- Not recommended
- Missed opportunity to install an air source heat pump
- Minimal, if any, efficiency or comfort improvement for cold climate applications

OPTIONS FOR AC REPLACEMENT

Single/Two Stage HP

Choose for:

- Low upfront costs
- Shoulder season heating only
- Cost-sensitive customers with natural gas and no electric heat or dual fuel rate option

Avoid for:

- Electric resistance or delivered heating fuels
- Electrification / decarb focus

- Good efficiency and comfort performance in shoulder season
- Lower up-front costs
  - If furnace replacement can still be avoided through brand-matching a rated pair to existing equipment
- Single stage heat pumps cannot increase compressor speed at cold temperatures
  - Capacity decreases with outdoor air temperature
  - Requires higher switchover temperatures
- May not have incentives available

OPTIONS FOR AC REPLACEMENT

Coil-only VSHP

Choice for:

- Avoiding upfront furnace replacement costs
- Fuel flexibility
- Improved cold weather capacity and comfort
- Partial electrification

Avoid for:

- Very cost sensitive customers with natural gas and no dual fuel or electric heat rates

- Drop-in option to pair with any furnace
- Less cost than full system replacement
  - Higher cost than AC only install
  - Similar or lower cost compared to SSHP with furnace replacement
  - Lower cost than communicating ASHP install
- Good performance in displacing about a third or more of the heating load
  - More heating capacity for oversized installs
  - Savings opportunity for high-cost fuels
- Comfort improvements likely across most of the year
- Incentives may only be available for 3-ton systems

OPTIONS FOR AC REPLACEMENT

Cold Climate ASHP

Choice for:

- Displacing high-cost heat fuels
- Low electric heat rates
- Right-sizing entire HVAC system
- Comfort improvements
- Efficient electrification & decarb
- Cooling season savings

Avoid for:

- Very cost sensitive customers with natural gas and no dual fuel or electric heat rates

- Highest cold weather capacity
  - Most effectively decarbonizes heating loads
- Operational savings in displacing electric resistance, delivered oil or propane fuel
  - Highest upfront costs
- Opportunity to right-size furnace and VSHP simultaneously
- Comfort improvements likely across most of the year
- Great incentives and tax credits available!

OPTIONS FOR AC REPLACEMENT

- Air Conditioner
- Single Stage HP
- Coil-only VSHP
  - New product class
  - Does not require furnace replacement
- Cold Climate ASHP

The market believes this segment will grow in the future

Customer awareness is moderate; awareness building is needed

An educational sales process is needed

Early adopters are out there and want this solution: never miss the chance to offer it

Upfront cost is critical to customers, leverage rebates, financing

Operational cost matters and customers are willing to pay more upfront for savings

Not all customers want to replace their heating and cooling at the same time: be prepared to offer solutions to these customers

Myth - HPs deliver low air temperatures

What you will take away from this section

- ❑ Comfort isn’t about delivered temps
- ❑ Comfort balance point and the customer experience
- ❑ Defrost can be supplemented / controlled
- ❑ Switchover temperature is set based on customer goals

Problem Statement:

Heat pumps don't deliver hot air:

Switchover temperatures are often higher than they need to be to avoid defrost, and to ensure higher customer experiences

Heat pumps deliver ***warm*** air!

Switchover temperature and 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 temperature at which the cost to heat the home with the HP is 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.

What is Comfort?

According to the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), thermal comfort is defined as “that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.”

If comfort is subjective, it means we can change the perception.

How can we change customer perception?

Understand the customers goals

Adjust air delivery points

Education / understanding

Set expectations

Understand customer goals

Customers that are operation cost-oriented:

Set balance point based on economics, keep the cost as low as possible

Customers that want to reduce emissions:

Set the thermal balance point low, keep the heat pump on as long as possible

Customers that want the most comfort:

Set balance point a little higher to have less defrost cycles

Design with comfort in mind

Cooler delivered air temperatures means the air will travel further into the room

Avoid blowing supply air directly on the occupants

Direct air flow into open spaces

Move toe kicks away from high use areas such as sinks

Install indoor units away from sensitive areas

Educate customers and set expectations

Ensure the customer understands the balance point

Ensure the customer understands defrost

Set expectations on customer operation of the heat pump

Set expectations for delivered air temperature

How heat pumps handle defrost cycles

Most common:

All-electric systems may engage strip heat to run to maintain delivered air temp

Dual fuel systems typically are set to at a certain temp and switch to furnace

Indoor fan may also stop for dual fuel systems

Understand the Defrost Cycle

Depending on which type of modern heat pump you have, you may not even notice the defrost function.

However, for some, the defrost function can be confusing. This is because when outdoor temperatures are below 40˚F, the outdoor unit will **accumulate** frost, but no need to worry because your heat pump is designed to defrost itself automatically. It will occasionally stop producing heat to melt ice from its outdoor surfaces. After a few minutes it will automatically begin making heat again.

What to expect during this defrost mode:

- Indoor fan stops
- Light on the unit may turn on or start blinking
- Water or steam may be seen at the outdoor
- Sounds coming from both indoor and outdoor units, such as "whirring," "clicking," "rushing fluid," etc.
- You may also hear outdoor unit's compressor make more noise than normal (without the fan running)
- Defrost cycle lasts 5 – 15 minutes, then the unit returns to normal heating operations

Do not be alarmed. Do not interfere with your heat pump's defrost function as that can delay its return to normal heating operations.

From "Top Ten Tips" brochure

Alternative auxiliary strip heat control

Supply air temperature sensor (SAT)

Advanced air handlers have SAT terminals

- 10-20K Ohm sensor
- Typically dip switch controlled (on control board)
- Set to 85 ^{o}F

Benefits:

Turns on resistance heat when needed to maintain supply air temps

DOES THE ENVELOPE MATTER?

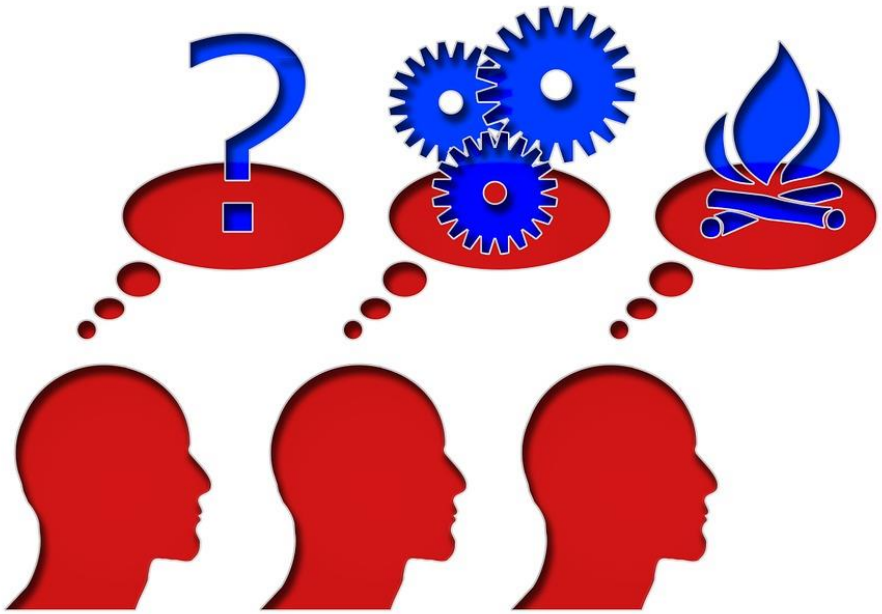
Considerations:

Where is the end of your heating system distribution?

What determines human comfort?

Gunnison - **Mean radiant surface temperature**, air temperature, humidity, clothing, metabolism

Do smaller sized heat pumps cost less?



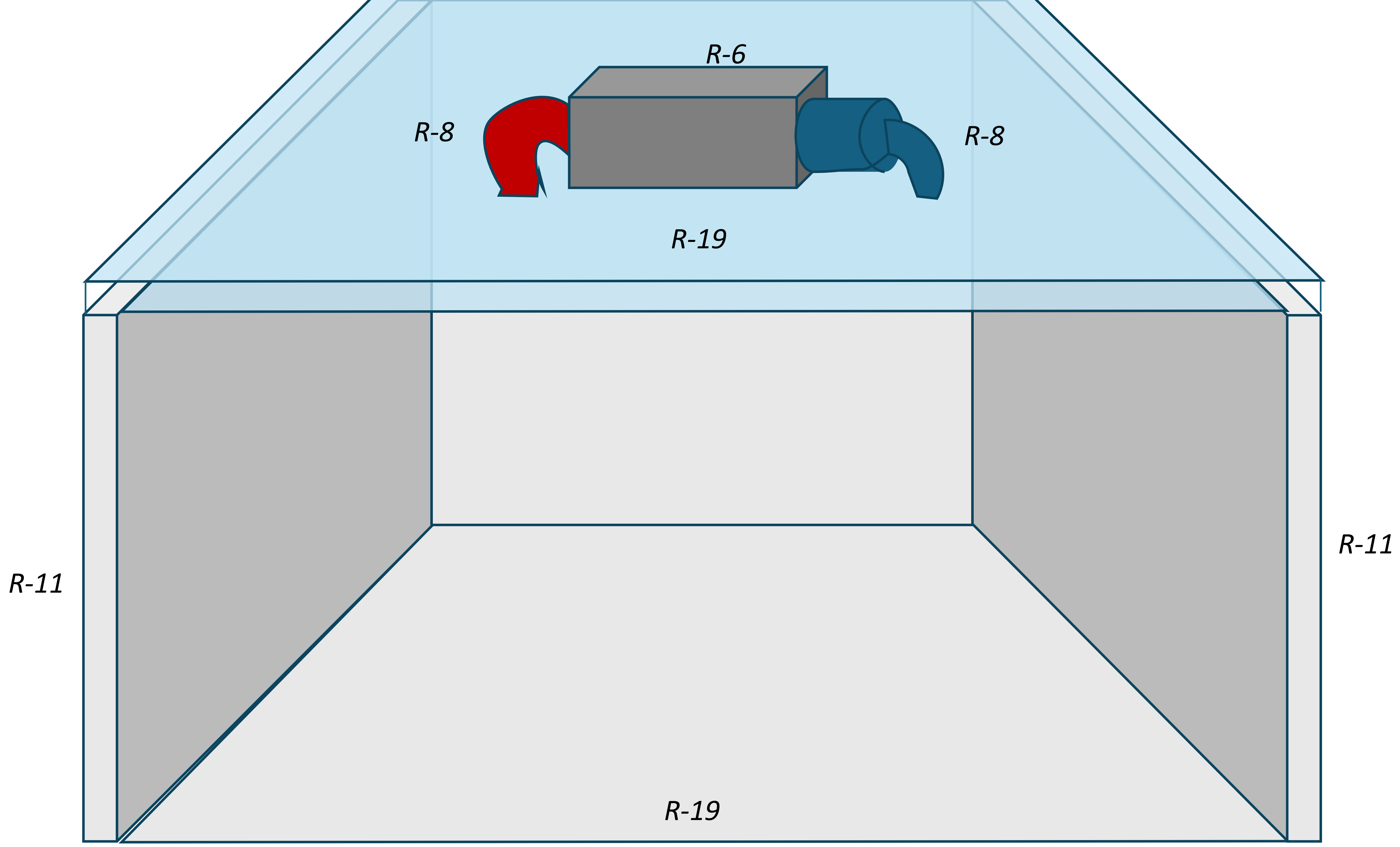
Why the envelope should matter to you!

Sizing and design is dependent on heating and cooling loads, and retrofits change those.

Homeowners often need help in planning retrofits over time.

New incentives and tax credits may encourage phased projects over time.

Comfort is not based on delivered air temperature and RH alone.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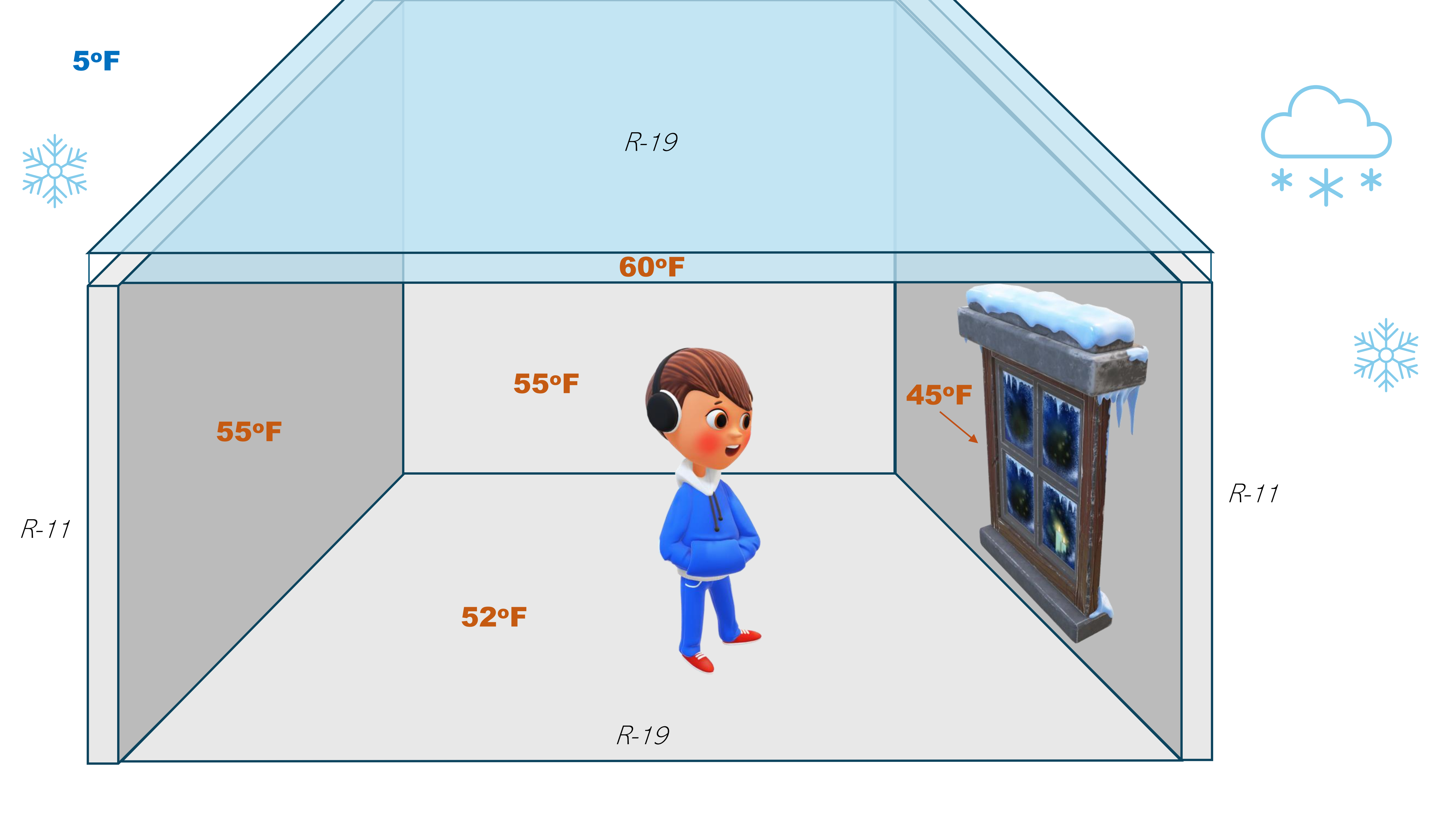
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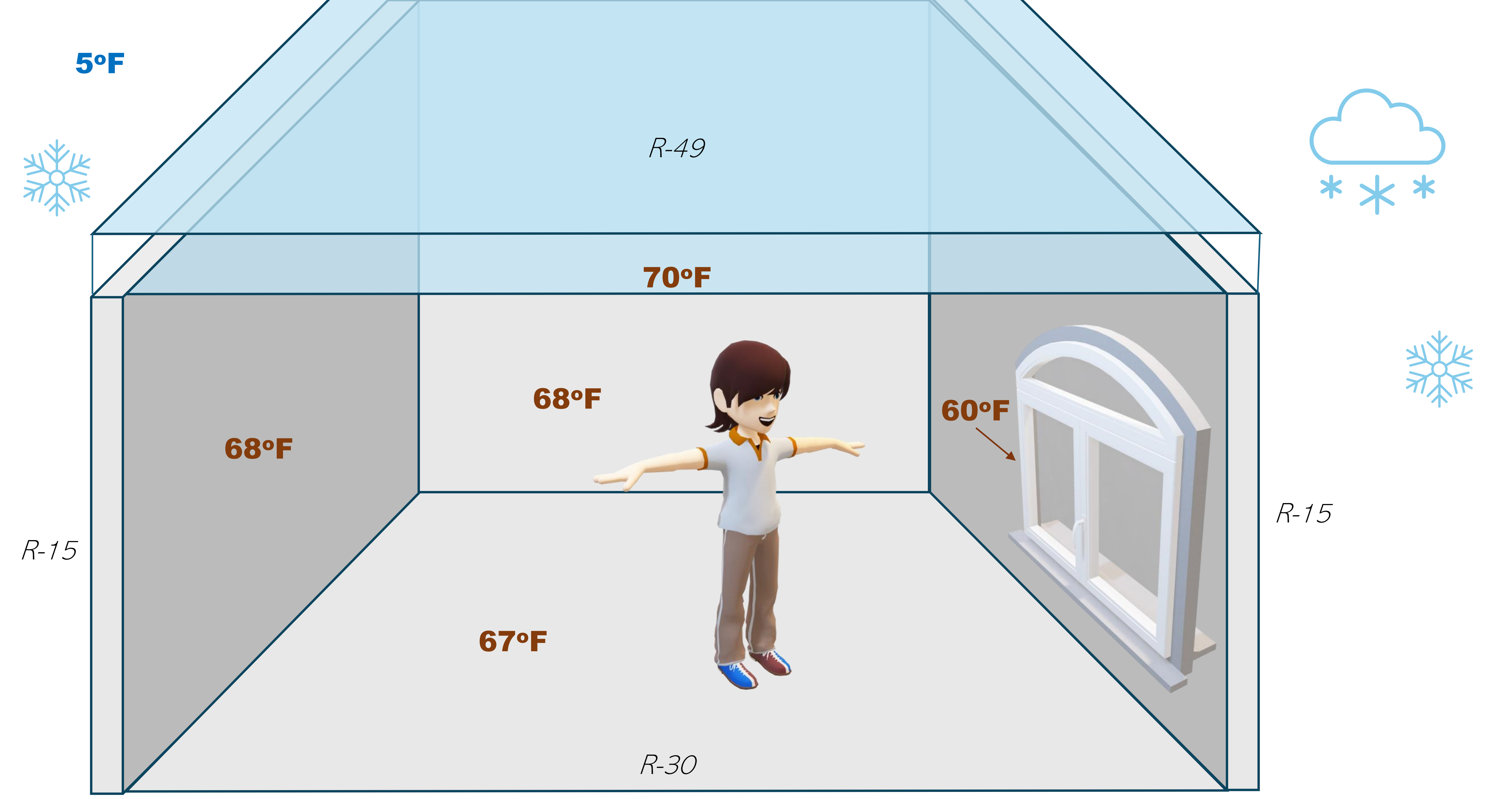

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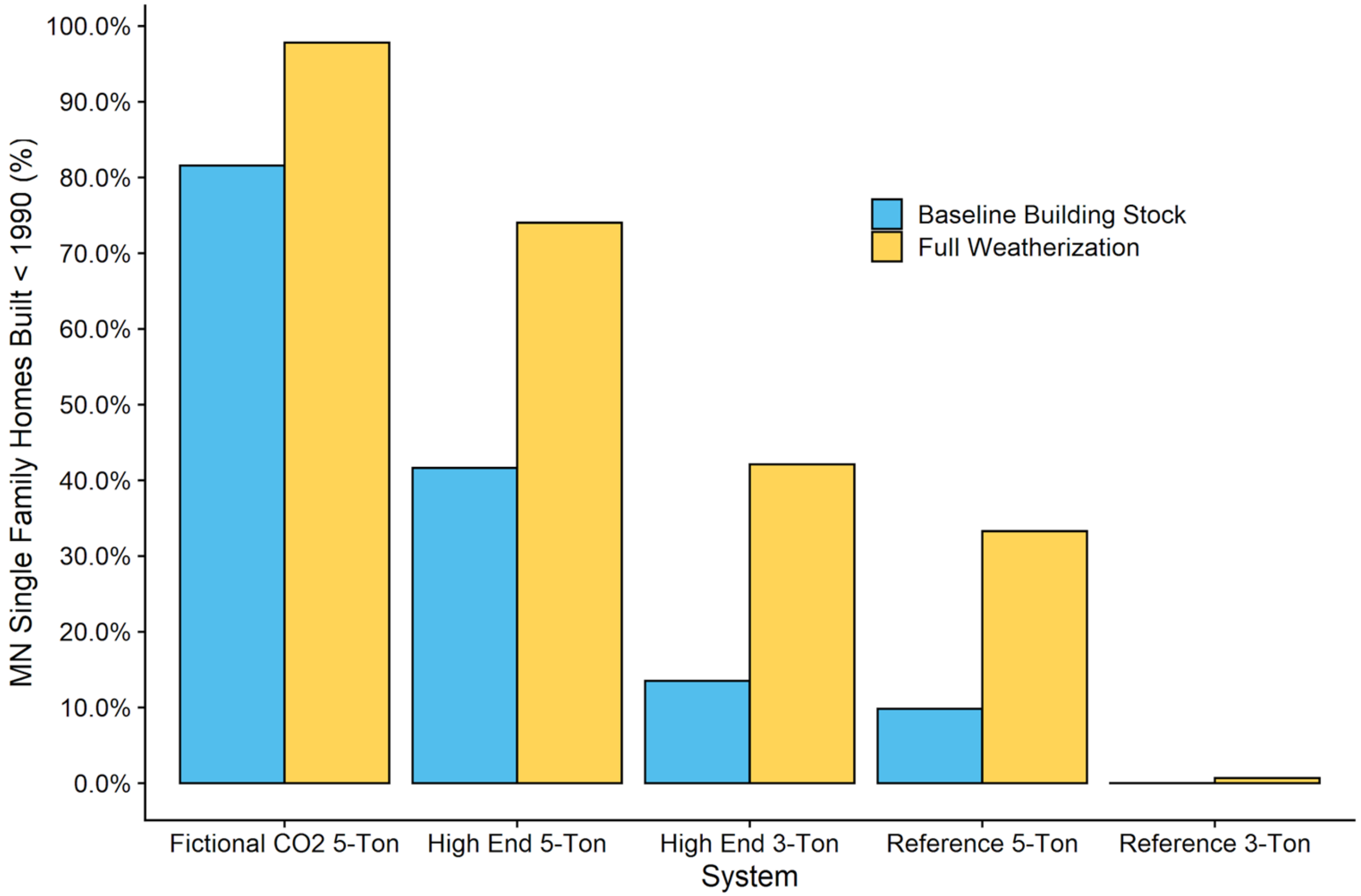
Envelope Improvements Show Results

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



From Minnesota work

When to install the heat pump?

Is the homeowner considering or willing to weatherize

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

Prioritize timing

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

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

Key takeaways from this section

Comfort is subjective and we can change the comfort balance point

Educate consumers based on goals

Adjust air delivery to affect the space not the people

Set proper defrost strategies

Set expectations around performance and defrost operation

Thank you

Additional question? Contact us

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