Pennsylvania Heat Pump Summit

Agenda

- **Welcome messages:** 8-8:25am
- **Industry Perspectives Panel:** 8:25-9:15am
- **Break:** 9:15-9:30am
- **Training Session 1:** 9:30-10:30am
- **Break:** 10:30-10:40am
- **Training Session 2:** 10:40-11:40am
- **Incentive Programs:** 11:40-12:00pm
- **Audience Discussion:** 12:00-12:10pm

Thank you to our:

Planning Partners

neep

EEA
ENERGY EFFICIENCY ALLIANCE
PENNSYLVANIA NEW JERSEY

slipstream

Venue Partners

eca ENERGY COORDINATING AGENCY

UA
UNIVERSAL AUDENRIED CHARTER HIGH SCHOOL

ENERGY EFFICIENCY ALLIANCE
PENNSYLVANIA NEW JERSEY

Who We Are

Mission

Our reason for existing

To champion efficiency as the foundation of a clean, just, and resilient energy economy.

Vision

The future we intend to help build

Energy efficiency anchors all efforts to meet our ongoing energy needs, improve health and comfort, promote energy equity, and protect our climate.

Values

The guiding principles for all we do

We support energy efficiency that grows strong local economies, helps create resilient communities and healthy buildings, addresses pressing environmental issues and advances an equitable, just and

The EEA "Family of Organizations"

EEA is a 501(c)(3) nonprofit.

What We Do:

- EEA works to increase energy efficiency awareness and encourage energy efficiency action.
- Educate public officials, regulators, other stakeholders about energy efficiency industry matters.
- Engage stakeholders and the business community.

KEEA and EEA-NJ are state-facing programs of a single **501(c) (6) trade association** for the energy efficiency industry.

What We Do:

- Advocate for and advance energy efficiency policy. (state-level lobbying)
- Serve our Membership.
- Convene our members to share best practices and to network

Why We're Here Today

- Heat pump technology has become more effective, efficient and comfortable for residents since the 1990s
- The market for heat pumps continues to expand
- Even without rebate programs, heat pumps have been shown to decrease long-term energy costs for consumers
- Despite a growing market and rebate programs:
    - Consumers are still skeptical
    - Workforce needs are evolving

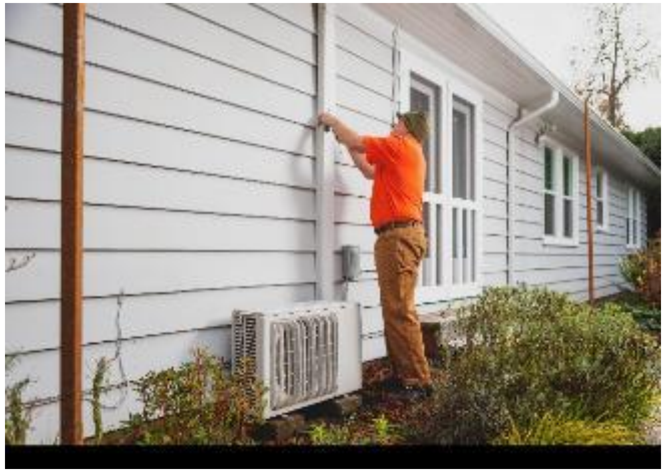
Goals for today's session:

- **Review the latest information about heat pumps**
- **Dispel common misconceptions**
- **Provide you customer-facing strategies to help you sell them**
- **Provide actionable insights to help you succeed in the growing heat pump industry**

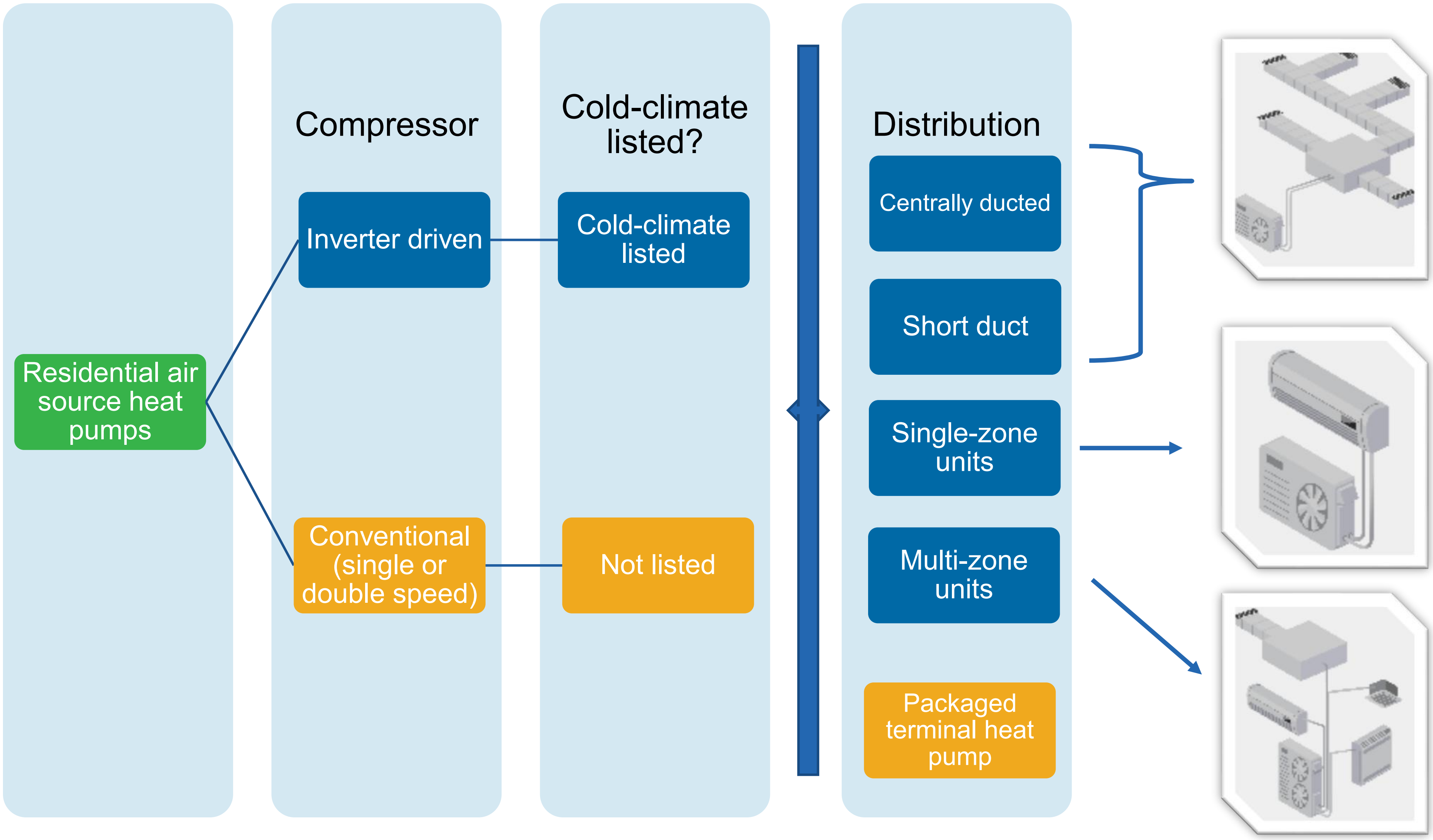
Technology and Market Overview

In Focus Today: Residential Air-Source Heat Pumps

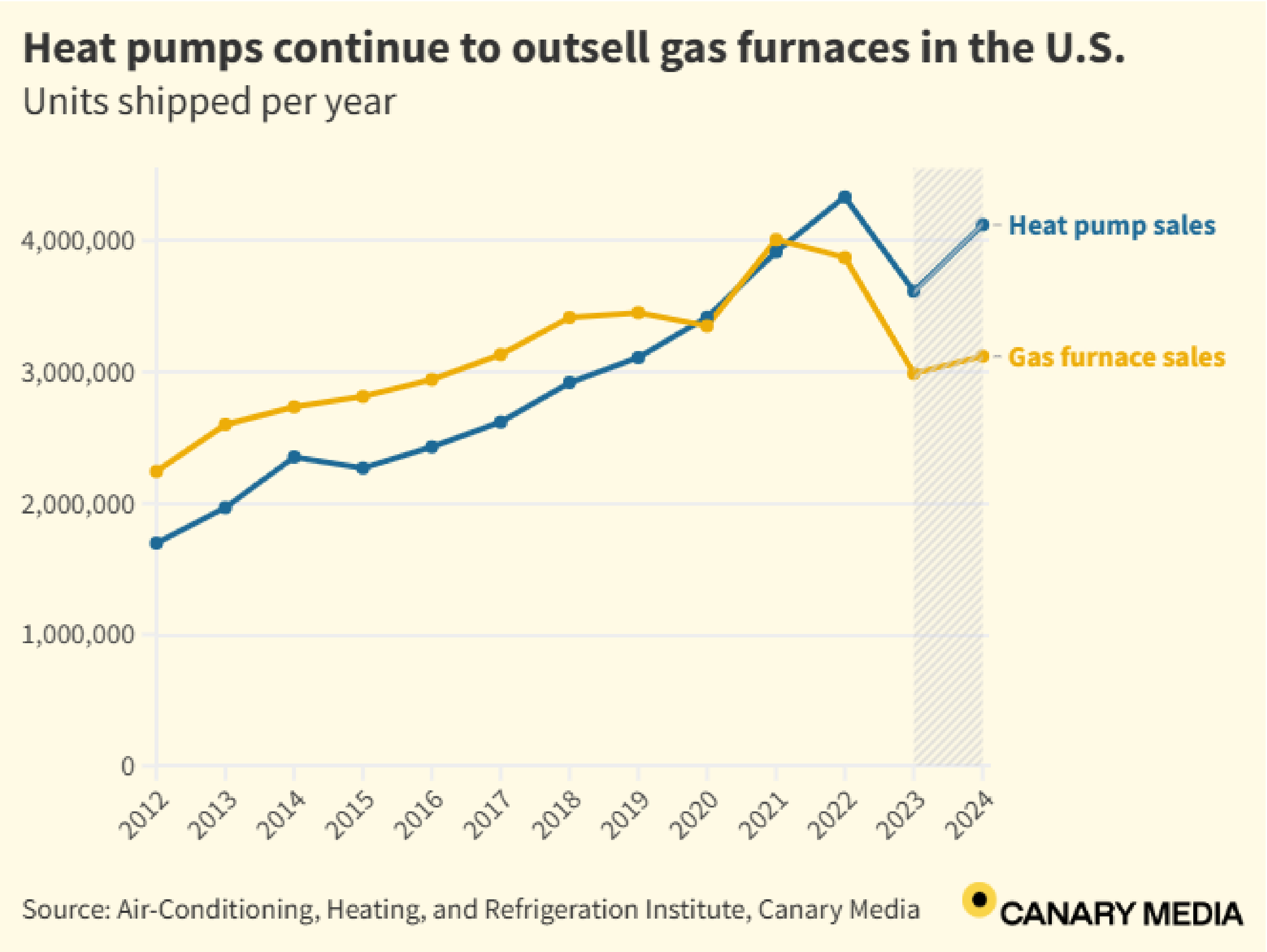
- **Residential heat pumps**
  - **Minisplit heat pumps**
  - **Centrally ducted heat pumps**
  - **Dual-fuel heat pumps**
  - Air-to-water heat pumps
  - Ground source heat pumps
  - Gas fired heat pumps
- Commercial heat pumps
  - VRF heat pumps
  - RTU heat pumps
- Industrial heat pumps



Residential Air Source Heat Pump Taxonomy



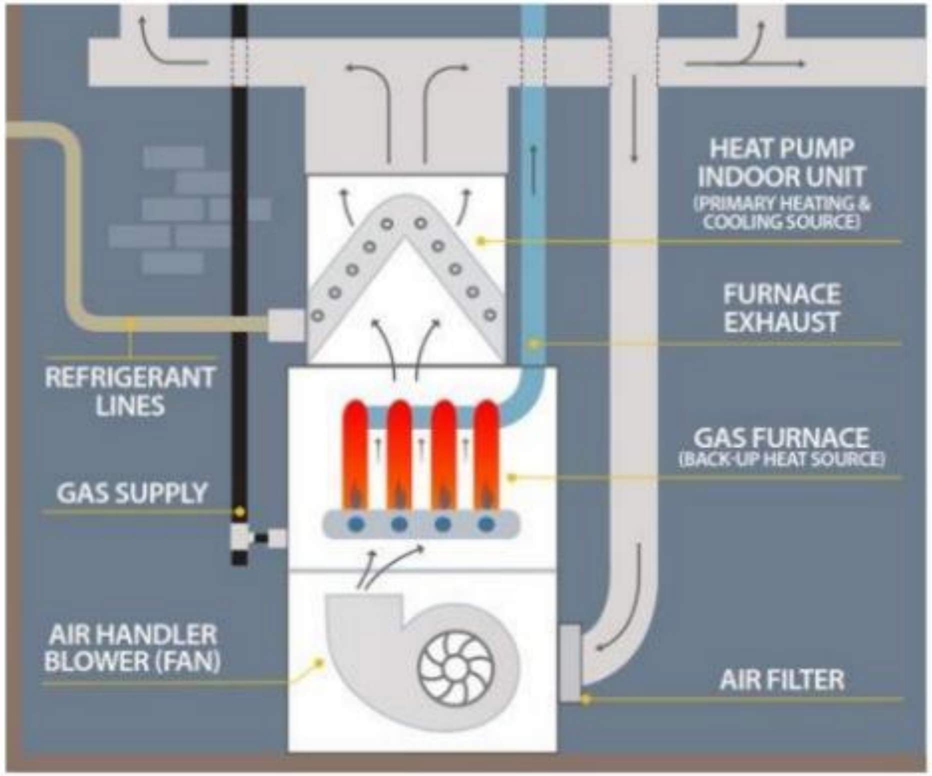
Heat pumps outsold gas furnaces by their biggest-ever margin in 2024



Takemura, A. F. (2025, February 20). *Heat pumps outsold gas furnaces by their biggest-ever margin in 2024*. Canary Media. https://www.canarymedia.com/articles/heat-pumps/heat-pumps-keep-widening-their-lead-on-gas-furnaces

Both title and interactive graph pulled from article

Hybrid (Dual Fuel) Heat Pumps



Type of Dual-Fuel Heat Pump	Model examples	Relative Cost	Cold-climate potential performance
Single or two-speed	Available from all manufacturers	Low	No
Modern inverter system	Top-tier from all manufacturers	Moderate to High	Yes
Standalone add-on inverter system (outdoor unit + indoor coil)	Bosch IDS Gree Flexx Mitsubishi Intelli-heat Samsung Hylex	Moderate	Yes
Multizone inverter system	Daikin VRV LIFE Carrier/Bryant Crossover Mitsubishi Intelli-heat	Moderate to High	Yes

FUTURE MADE BY HAND

PENN COLLEGE

Pennsylvania College of Technology
A Penn State Affiliate

Inspiring and preparing Tomorrow Makers—the next generation of industry leaders—with real-world experience and innovative spirit.

WORKFORCE DEVELOPMENT

Extend the mission

Provide workforce development solutions that improve the skill levels and competitiveness of our clients

- Non-degree and incumbent worker training, certification, and upskilling
- Technical assistance consulting and projects

WORKFORCE DEVELOPMENT

PRE-APPRENTICESHIPS AND WORKFORCE READINESS

CUSTOM TRAINING AND MICROCREDENTIALS

APPRENTICESHIPS

1 – 4 YEARS (10 REGISTERED PROGRAMS)

5,453
ENROLLMENTS

42
STATES

28
COUNTRIES

500+
UNIQUE COMPANIES

Pennsylvania College of Technology
A Penn State Affiliate

Program Areas

- Manufacturing
- Plastics
- Building Performance
- Health Sciences & Emergency Services
- Transportation
- WEDnetPA partner
- Business & Leadership
- Computer Skills

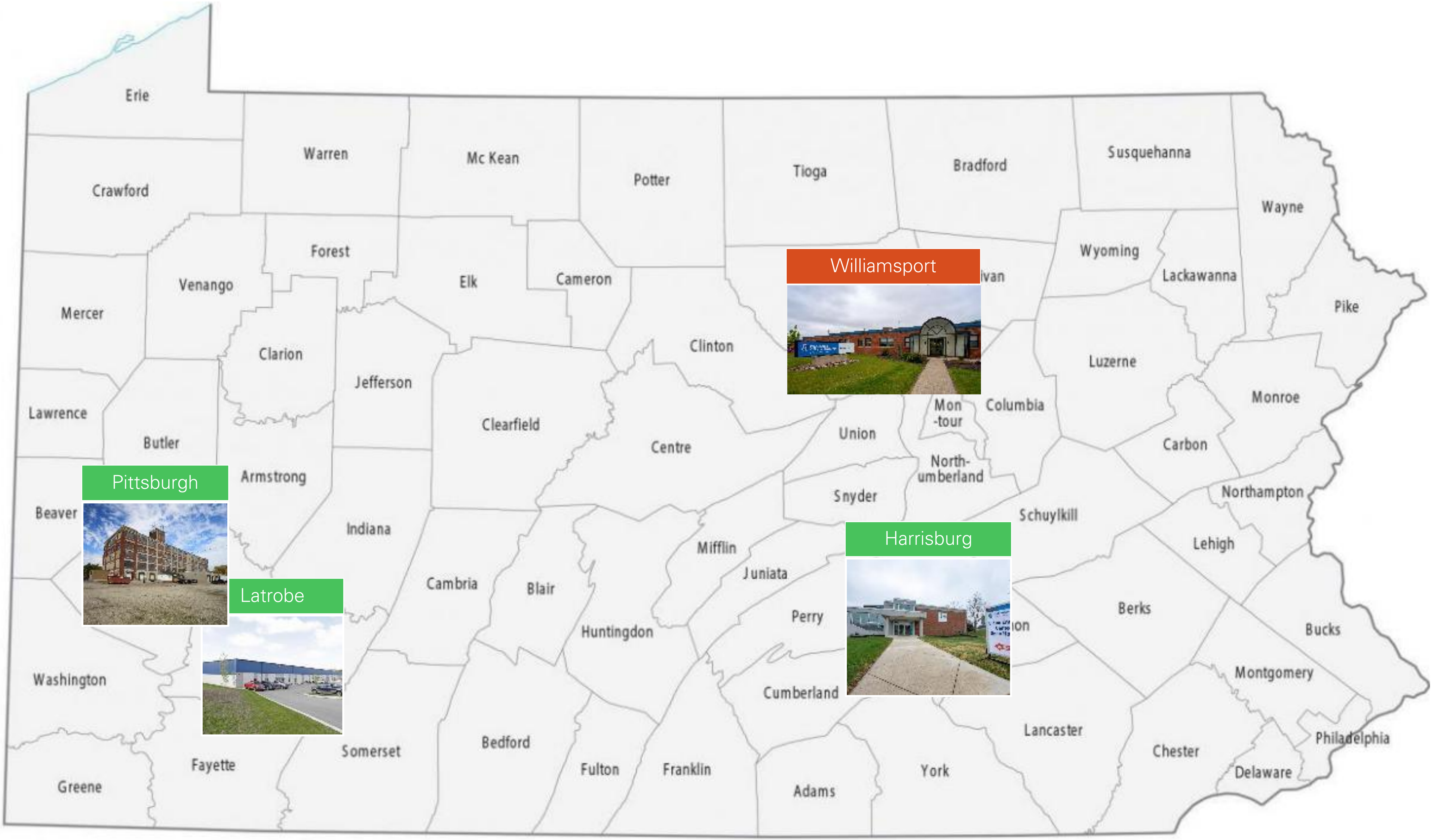
Building Performance

- Home Energy Professional training and certification
- Building science & energy efficiency training for the building trades
- Facilities Building Operator Certification
- Energy Specialist apprenticeship
- CTE career readiness initiative

Mission

- Our mission is to equip the ever-evolving clean energy workforce with knowledge, skills, and abilities to create healthy buildings, occupants, and communities through energy

LOCATIONS



Williamsport
Pittsburgh
Latrobe
Harrisburg
Erie
Warren
Mc Kean
Potter
Tioga
Bradford
Susquehanna
Wayne
Crawford
Forest
Venango
Elk
Cameron
Wyoming
Lackawanna
Pike
Mercer
Clarion
Jefferson
Clinton
Luzerne
Lawrence
Butler
Clearfield
Centre
Union
Mon
-tour
Columbia
Monroe
Carbon
Armstrong
North-
umberland
Snyder
Northampton
Beaver
Indiana
Schuylkill
Mifflin
Juniata
Lehigh
Cambria
Blair
Huntingdon
Perry
Berks
Bucks
Washington
Montgomery
Cumberland
Lancaster
Somerset
Bedford
Philadelphia
Fayette
Chester
Greene
Fulton
Franklin
York
Delaware
Adams

an Economic Development Nonprofit serving Western Pennsylvania

Pittsburgh Gateways
identifies unrealized potential and creates economic pathways by ***connecting people, places, and communities***

Karen Benner,
Director of Building Performance Programs

Holly Merriman,
Program Manager of Workforce Initiatives

Onsite Partnership in Pittsburgh

Penn College Workforce Development partnered with Pittsburgh Gateways to co-develop the **Building Performance Lab** as a:

- **training facility,** to deliver the full slate of the Penn College building science training programs to current & future workers.
- **recruitment resource,** providing outreach to students and adults of all ages considering career paths in the residential building industry.
- **business incubation hub,** for contractors and partners seeking to expand their capacity through apprenticeship-style opportunities and business development support.
- **community engagement platform**, informing community members of the opportunities to improve the health, safety and efficiency of their homes.

Pittsburgh Gateways Initiatives

Contractor Growth & Support

Recruiting, Hiring, Mentoring, Training, Retaining

Access to Funding & Supportive Services

Business Development, Operational Efficiency, KPI's

Navigating Rebates & Tax Incentives

Healthy Housing, Electrification

Duquesne Light Company

ROCIS

CMU Center for Building Performance & Diagnostics

Women for a Healthy Environment

Pitt School of Public Health

Community Engagement

Trade Institute of Pittsburgh & other entry-level training providers

Community Development Groups, Participation on CTE Advisory Boards

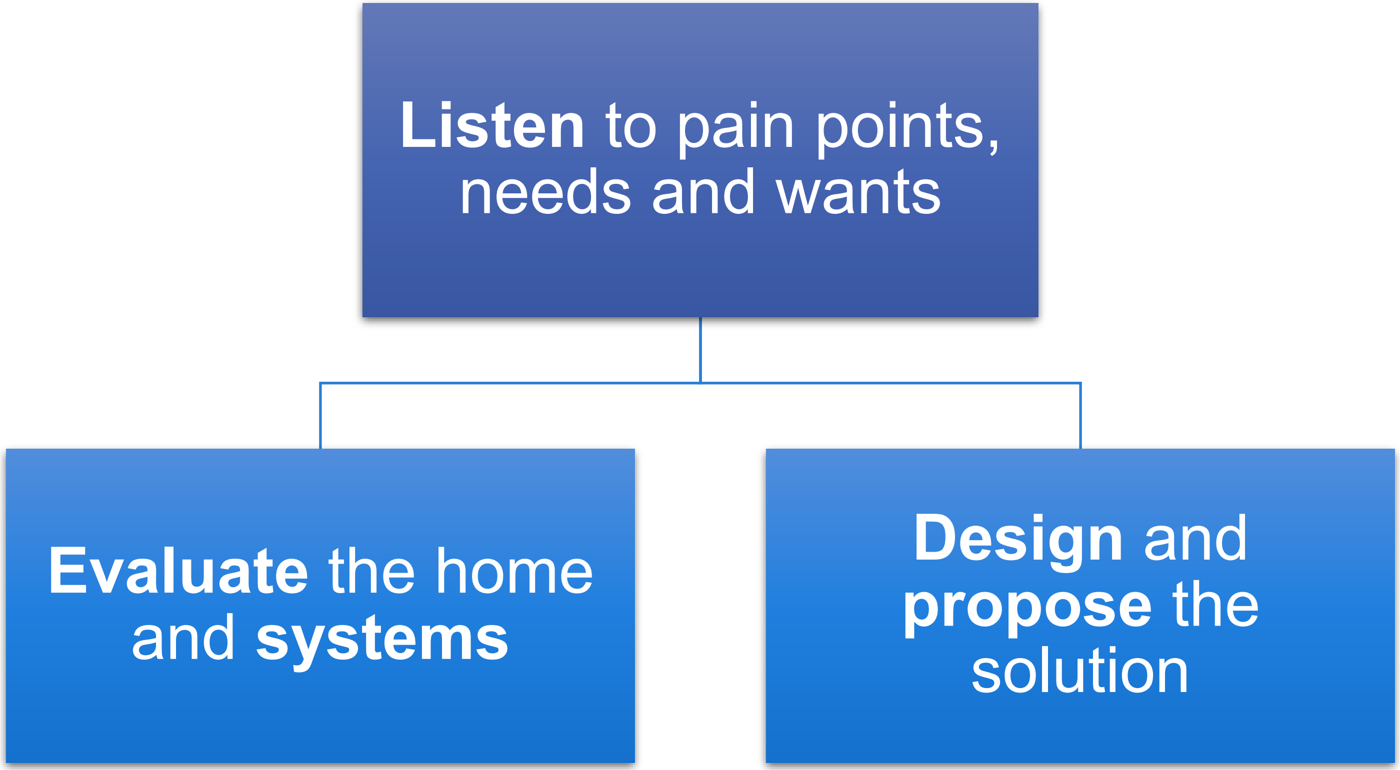
Industry Perspectives Panel

Training Curriculum


Right Sizing Journey
1
Identify homes loads.
Identify resident wants and needs.
2
Recognize applications and limitations.
Identify fuel types.
3
Evaluate equipment that can meet goals.
Determine how far residents wish to go.
4
Install properly.
Educate residents to operation.
Set controls.


Right Sizing Journey
1
Identify homes loads.
Identify resident wants and needs.
2
Recognize applications and limitations.
Identify fuel types.
3
Evaluate equipment that can meet goals.
Determine how far residents wish to go.
4
Install properly.
Educate residents to operation.
Set controls.

A Deeper Look at Pain Points, Needs and Wants



The Bullseye Pie of Customer Decision-Making

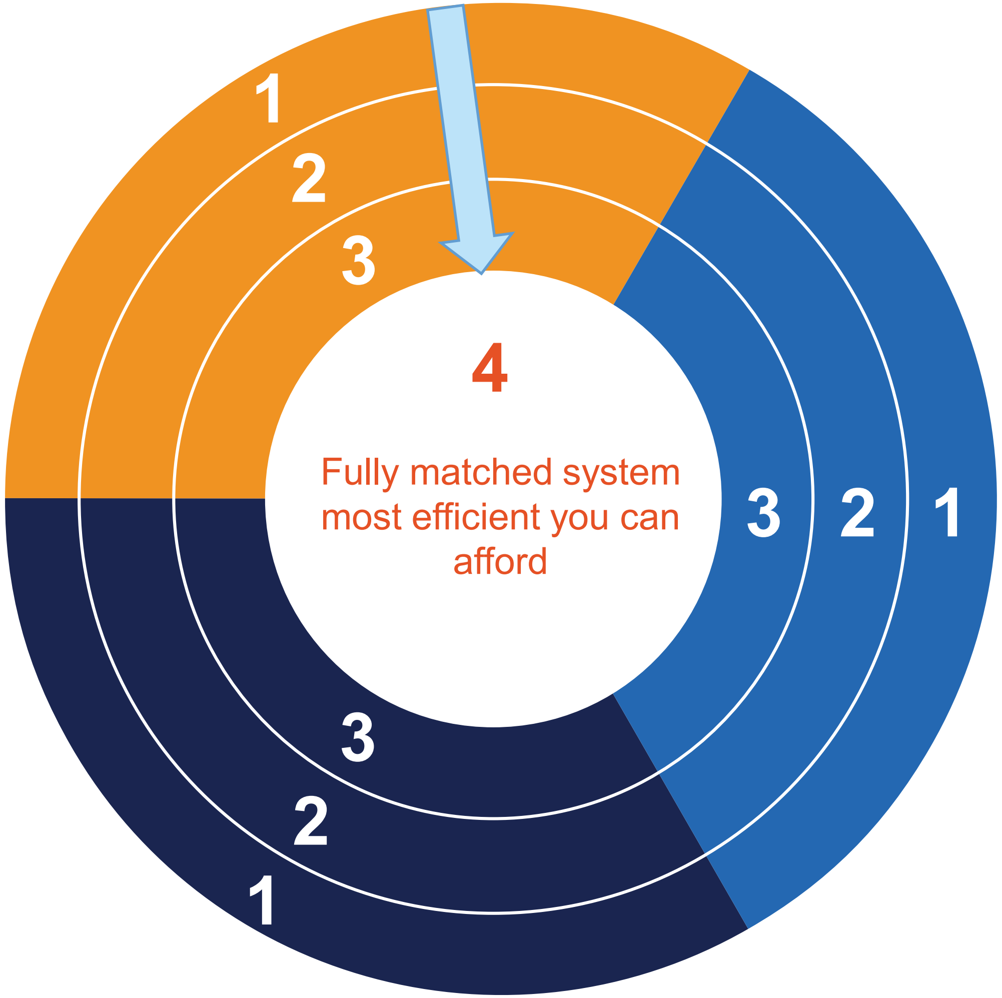
Single-Family Homes with fuel-fired forced air HVAC

Furnace Replacement

1. Multi-stage furnace at least as efficient as legacy
2. Multi-stage furnace & tune up remaining equip
3. More efficient furnace & compatible with future high efficiency heat pump

Planned Replacement

1. Load reduction and tune up legacy equipment
2. Single system replacement and tune up remaining equip
3. Fully matched system more efficient than legacy



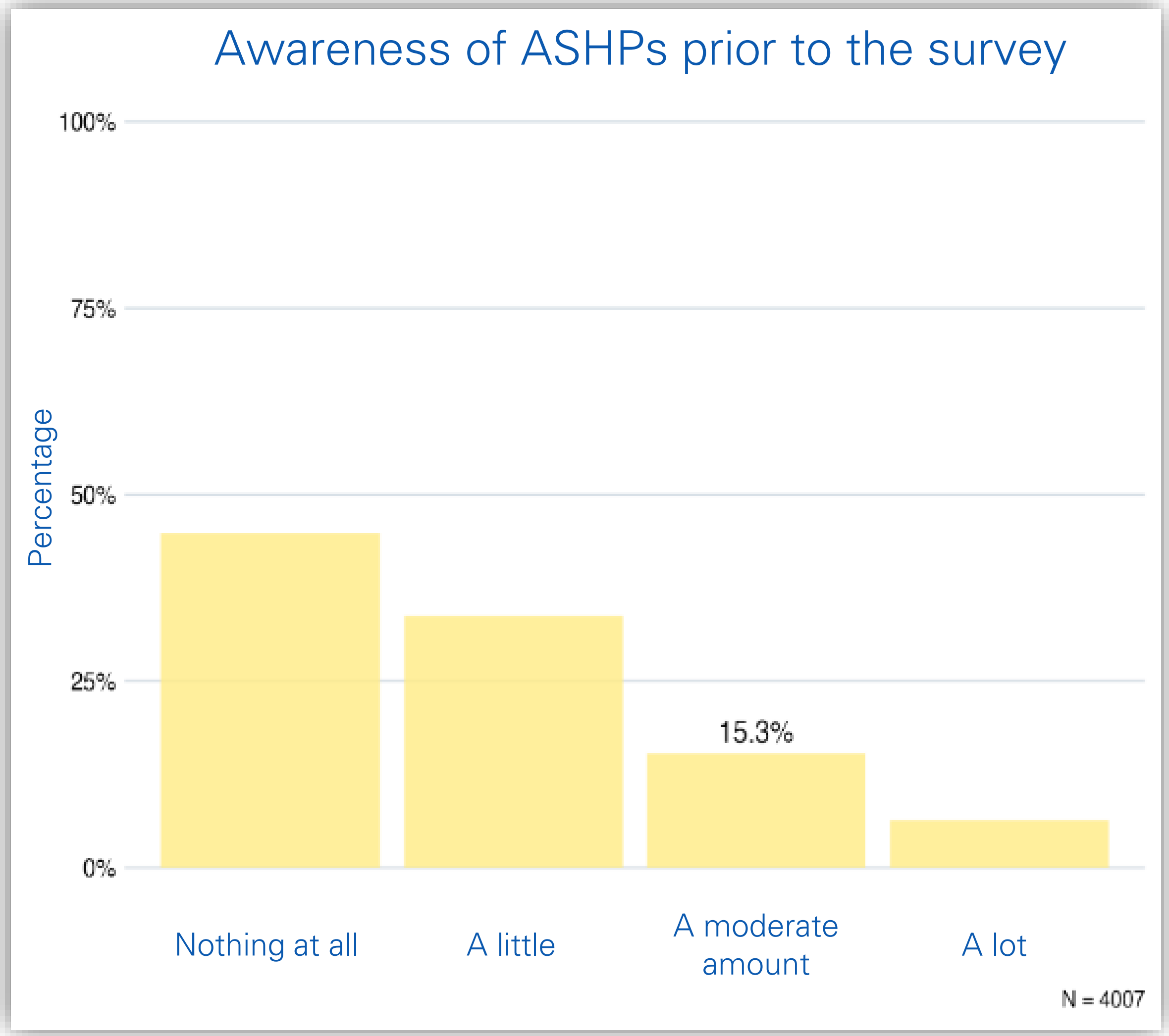
AC Replacement

1. Heat pump at least as efficient as legacy AC
2. Heat pump & tune up remaining equip
3. More efficient/inverter heat pump to improve comfort and/or improve operational costs

MIDWEST COLLABORATIVE

78% of survey participants knew little to nothing about ASHPs.

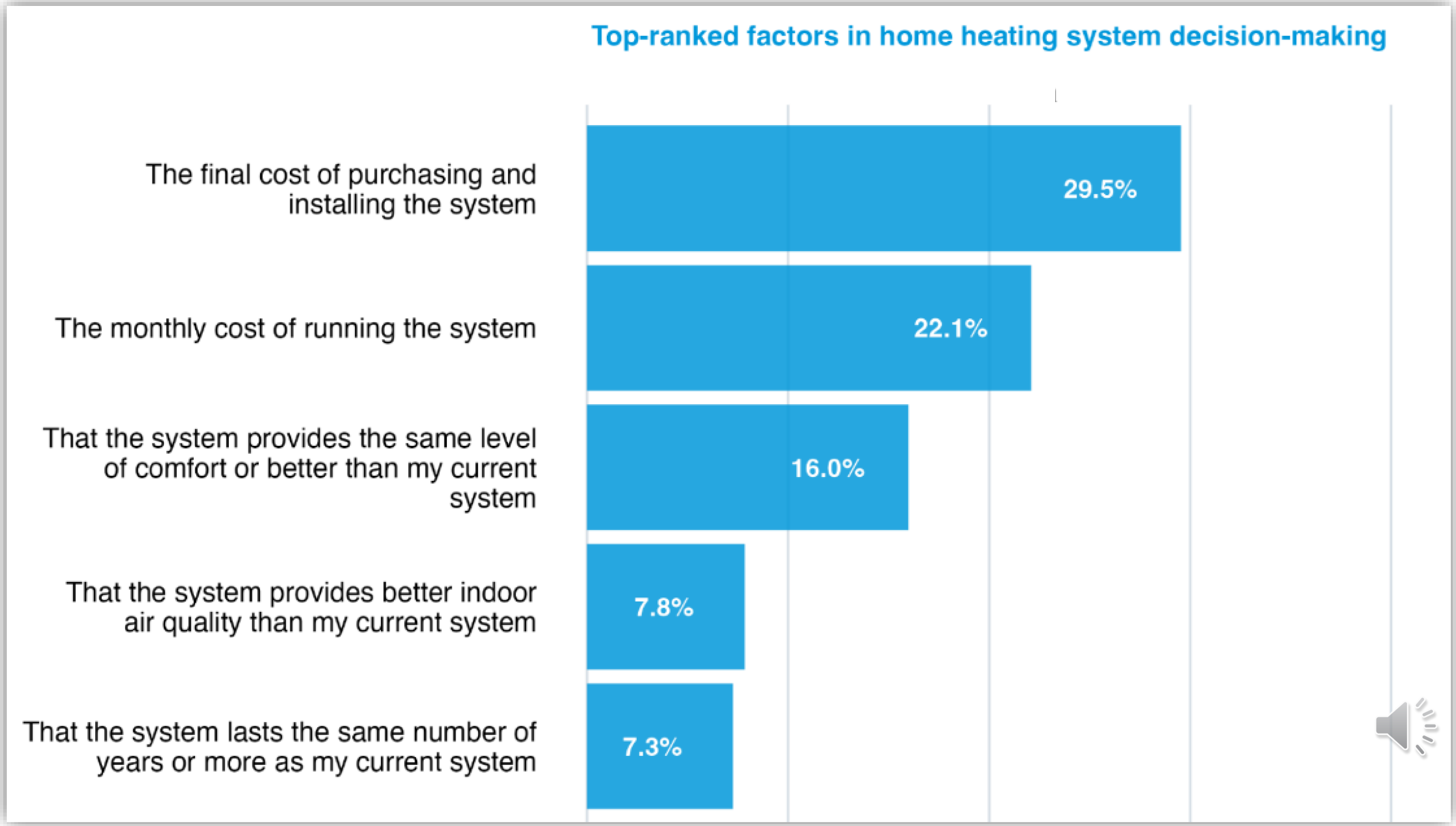
The work is not about saying the perfect thing to the perfect homeowner, the work is **normalizing heat pumps and piquing interest and conversation.**



Cost is the number one consideration for upper Midwesterners when choosing a home heating system.

Beyond installation costs, homeowners are also curious about:

- How heat pumps can maintain current comfort level
- How heat pumps can improve indoor air quality
- The longevity of heat pumps
- How their current contractor can continue service & maintenance


Top-ranked factors in home heating system decision-making
The final cost of purchasing and installing the system
29.5%
The monthly cost of running the system
22.1%
That the system provides the same level of comfort or better than my current system
16.0%
That the system provides better indoor air quality than my current system
7.8%
That the system lasts the same number of years or more as my current system
7.3%

The Customer First *Thinking* Process

Empathize

- Understand the concerns of the client
- Allows designers to set aside assumptions

Define

- Synthesize observations and inspection
- Define the problem statement for the customer

Ideate

- Identify and develop solutions to the problem statement
- Brainstorming and “worst idea” concepts are useful

Prototype

- Design scaled down versions of solutions to compare
- Bring ideas to team and client before developing complete solution

Test

- Redefine one or more problems to see if the solutions solve them
- Continue refining based on increased understanding of clients

MI HEAT PUMP COLLABORATIVE

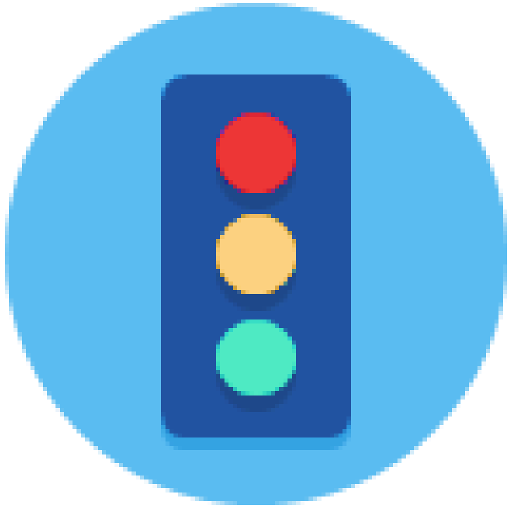
Sizing, design, and selection is often done based solely on rules of thumb and based on previous sized systems.

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

Current Common Approaches to Load Calcs:

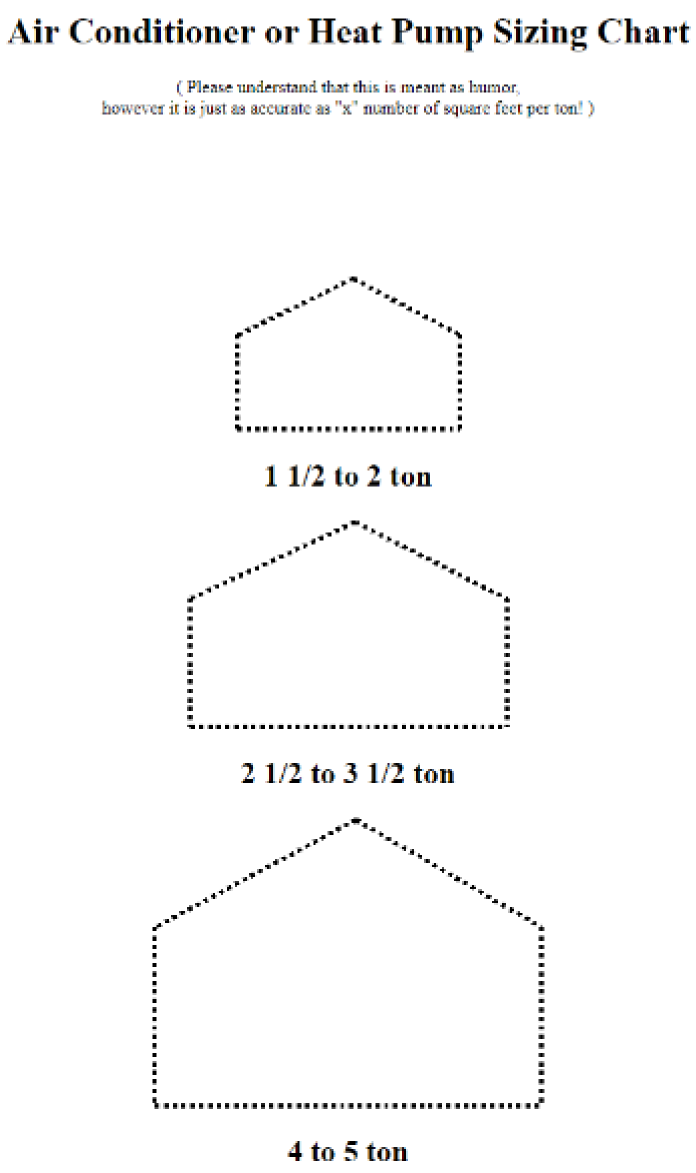
What People are Putting in it Most Often

- “Shoot from the hip”
- Sized off existing equipment size
- Using rules of thumb
- Utility bill analysis
- Block load calculation



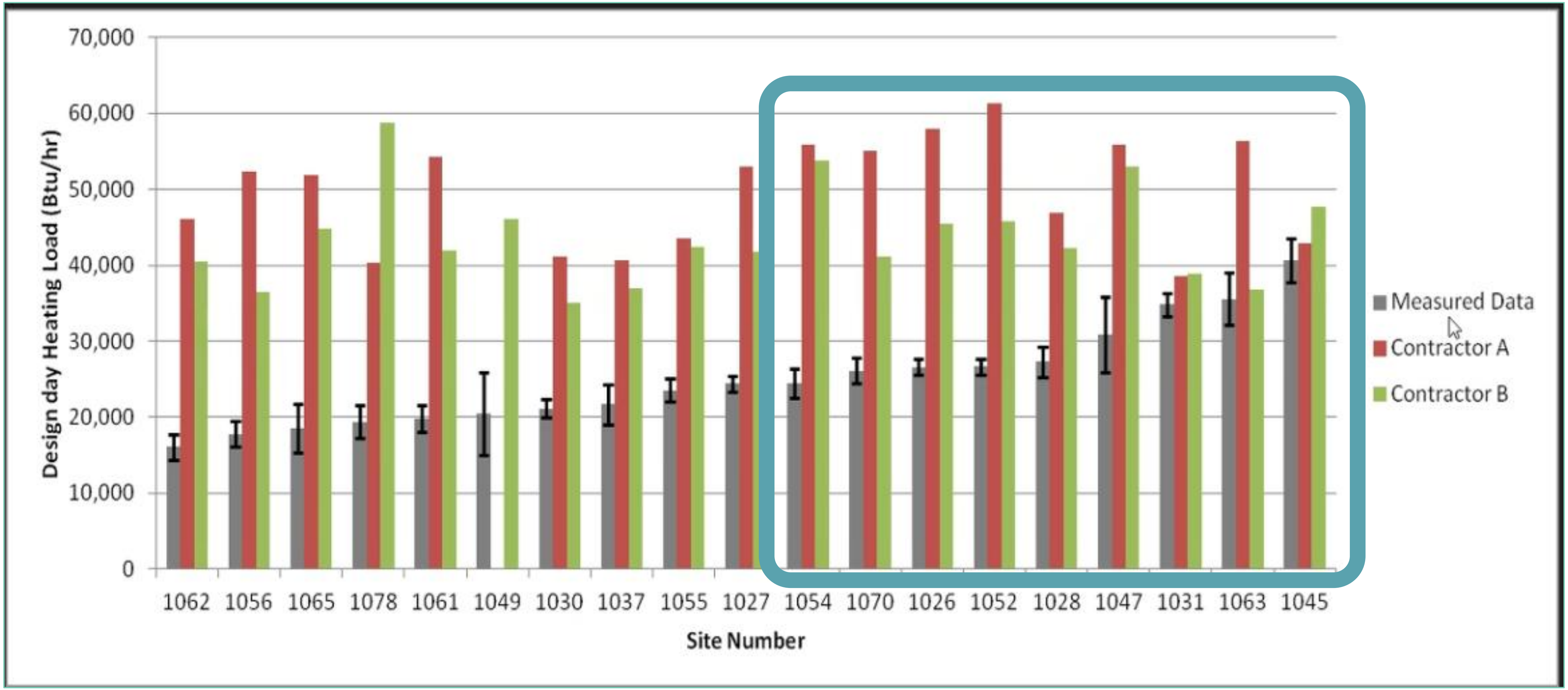
Sizing – Rules of Thumb

- One thousand BTU per 100 sq ft
- One cfm per sq. ft. of house
- 35 btu per sq ft
- Tonnage = half the number of cylinders in the customer’s biggest car/truck
- What's in the shop today
- ½ ton bigger than their neighbor



Slide courtesy Bruce Manclark

Concerned that Manual J Won't Size Large Enough?

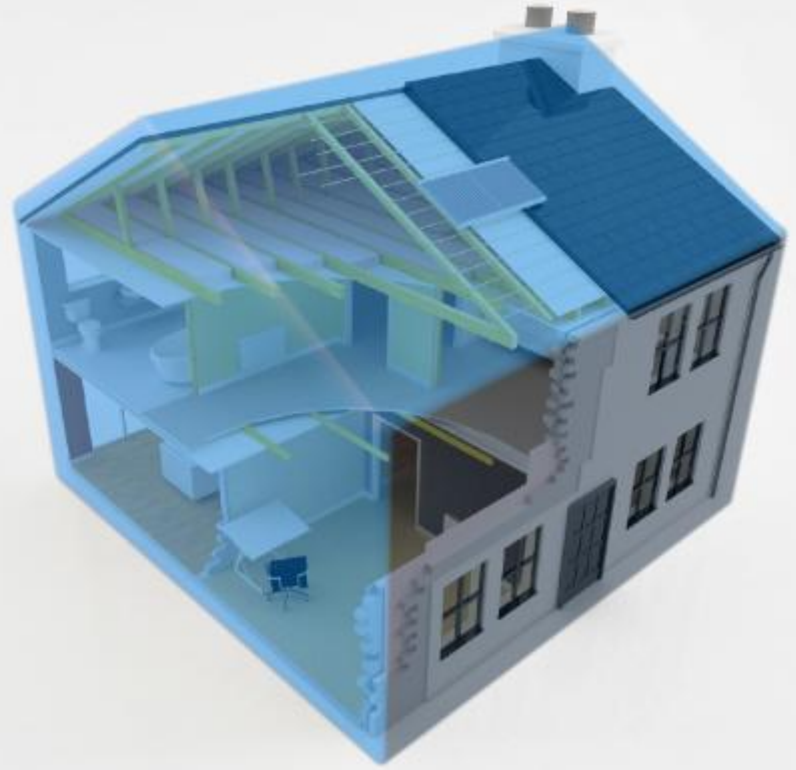


Low quality methods

- Duplicating existing equipment size
- A rule of thumb
- The Heating Load Estimator

Medium quality methods

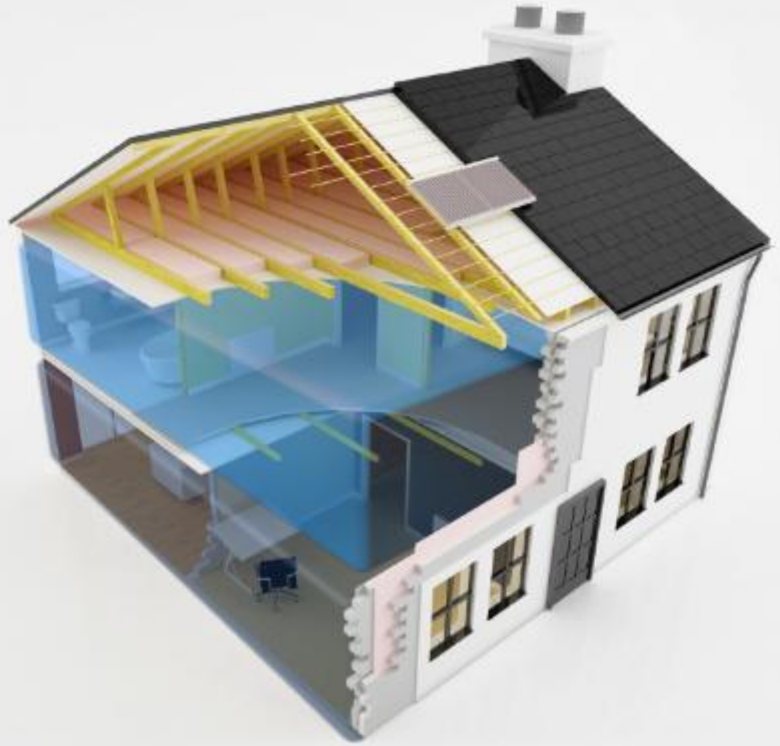
- Comfort consultation
- Block load calculation
  (Manual J or equivalent)
- Account for detailed building
  envelope information
- Factor in design temperatures



High quality methods

- Comfort consultation
- **Comfort Survey**
- Room-by-room Manual J or equivalent
  - Account for detailed building envelope information
- **Ductwork evaluation**
- Factoring in existing equipment's run time or customer's utility bills
  - When applicable
- Factor in design temperatures

"The Home as a System"

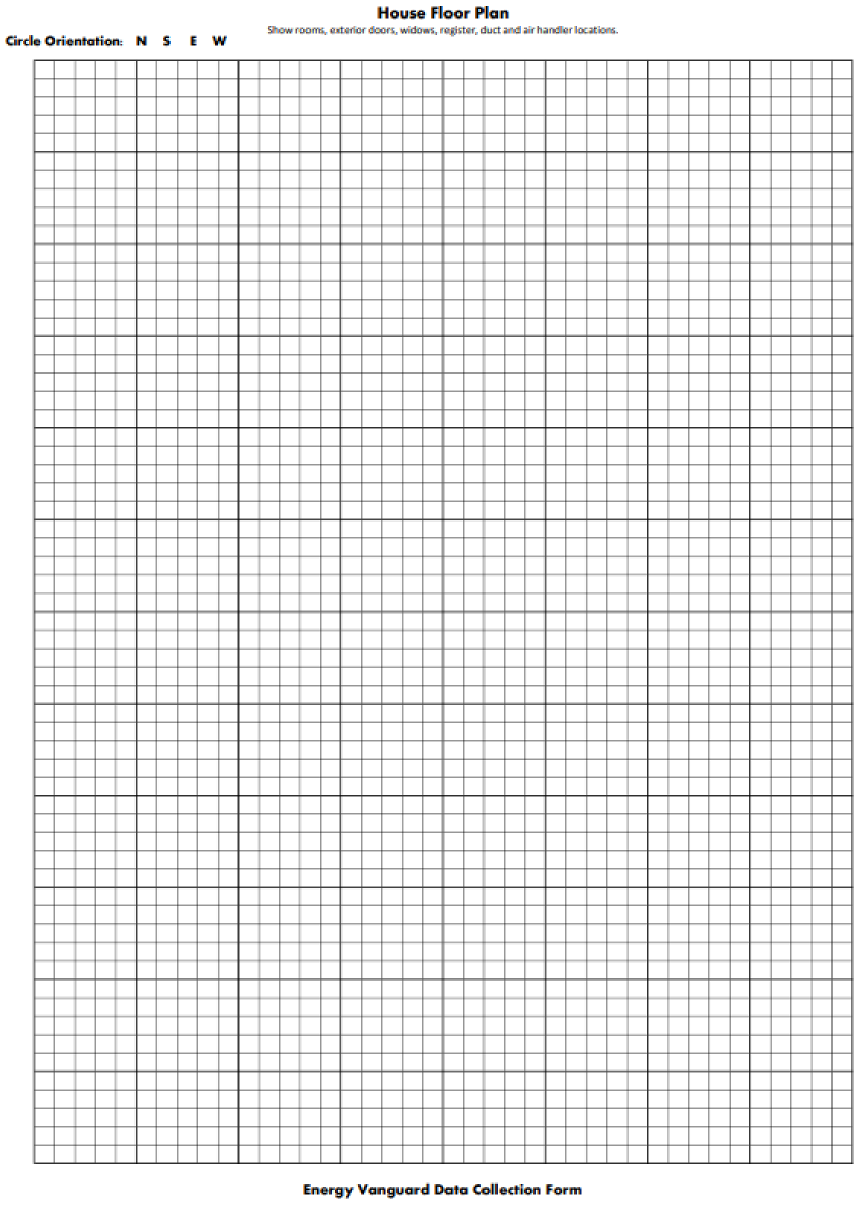


Data Collection: Three Primary Steps

From Energy Vanguard Available to download from their website

1. Start with house drawing, then
2. Move on to home data collection, then
3. Move on to system data collection

https://www.energyvanguard.com/hvac-design/data-collection/

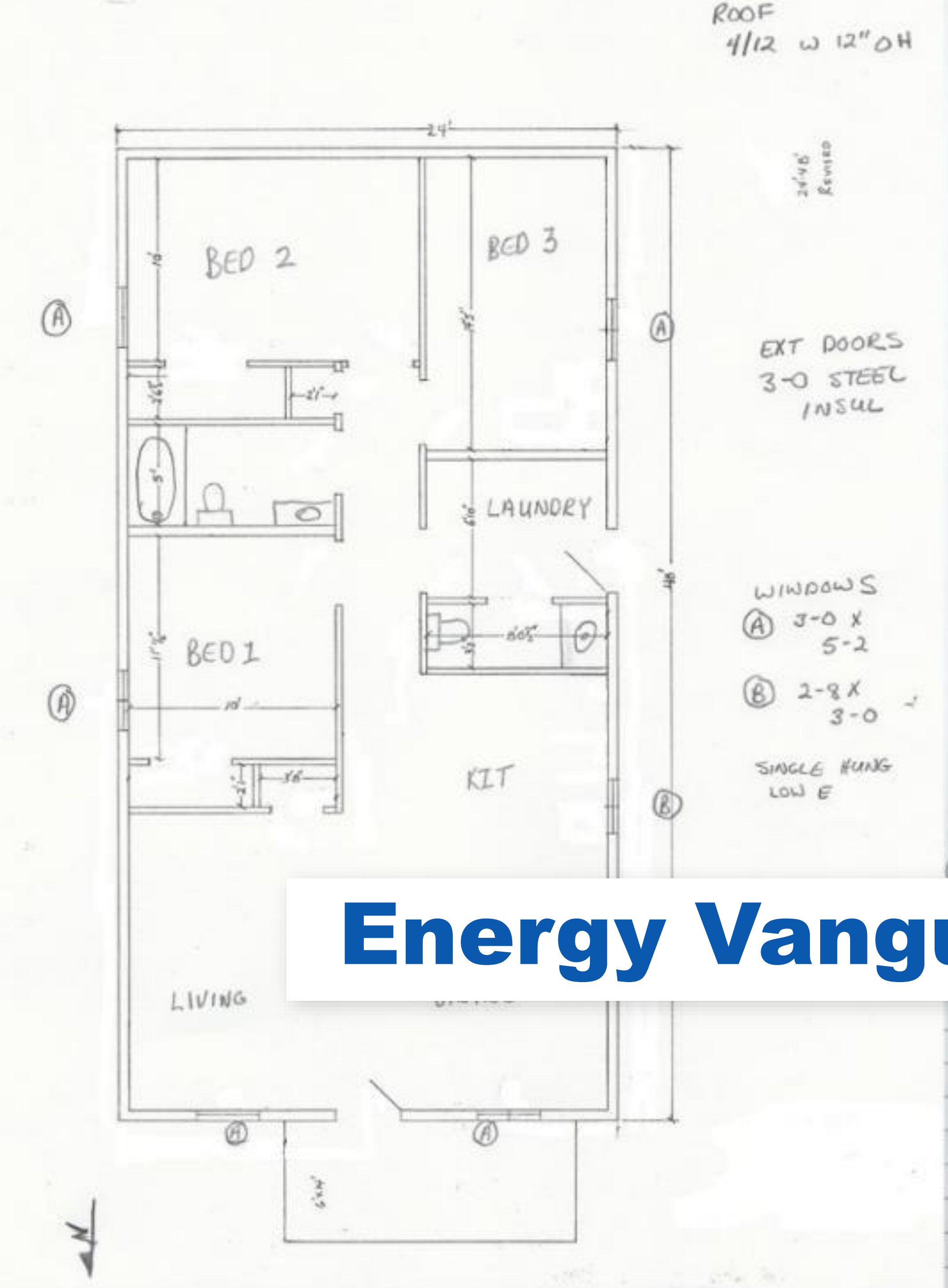

House Floor Plan

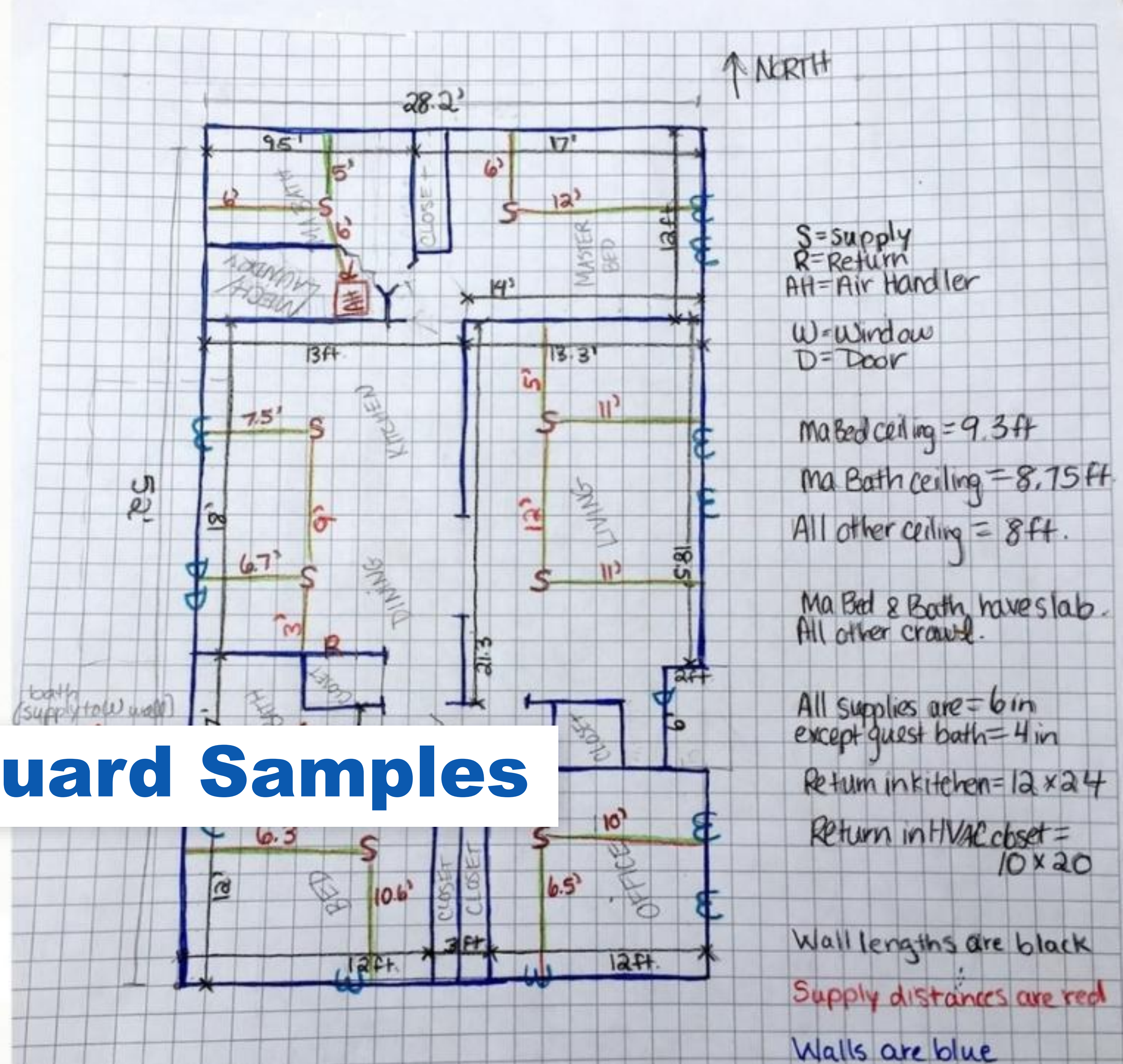
Show rooms, exterior doors, widows, register, duct and air handler locations.

Circle Orientation: N S E W

Energy Vanguard Data Collection Form

Energy Vanguard Samples





Energy Vanguard
533 W Howard Ave, Suite E, Decatur, GA 30033
hvac@energyvanguard.com · (404) 428-3393

Manual J Data Collection Form for New Homes

Date			
Data Collector		Contact #	
Homeowner / Builder		Contact #	
Property Street Address		Code Year	
City, State & Zip Code			

1. Front Door Faces

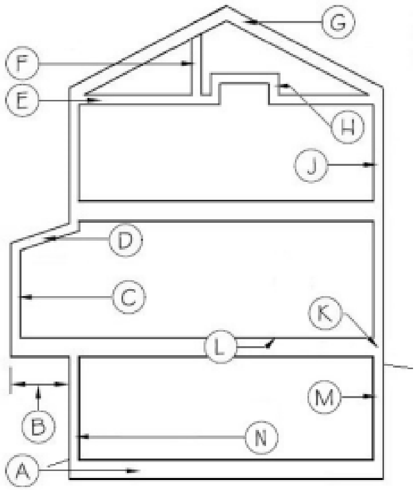
N☐	NE☐	E☐	SE☐	S☐	SW☐	W☐	NW☐

2. Home Description

3.Air Infiltration Rate

Blower Door @ cfm50		or	☐Tight	☐Semi-Tight	☐Average

4. Insulation



Location	Type	R-Value: Cavity	R-Value: Continuous
A: Slab Under			
Slab Edge			
B: Cantilevered & Frame Floors			
C: Exterior Walls, above grade			
D: Vaulted or Sloped Ceilings			
E: Flat Ceilings (typical blown attic)			
F: Attic Knee-walls			
G: Roofline (typical spray foam)			
H: Tray Ceiling Top/Side			
K: Rim/Band Joists			
L: Floor over Bsmt/Crawl/Garage			
M: Poured Bsmt or Crawl Walls Cavity			
Continuous ☐Exterior ☐Interior			
N: Framed Bsmt Walls			

XPS Extruded Polystyrene
EPS Expanded Polystyrene
ISO Polyisocyanurate
FGB Fiberglass Batts
BLN Blown Fiberglass/Cellulose
OC Open Cell Foam
CF Closed Cell Foam

5. Mark additional energy saving features present: ☐conditioned crawlspace, ☐encapsulated attic, ☐reflective shingles, ☐attic radiant barrier, ☐Energy Star home, ☐other above code certification program, ☐fireplace (sealed combustion), ☐fireplace (vented w/ outside air),
☐other: ____________________________

6. Solid Doors (Only for information not on plans)

	Description	Location	Size (W x H x Thick)	☐R or ☐U-Value
Type 1				
Type 2				
Type 3				
Type 4				

7. Windows & Glazed Doors (=>50% glass) (Only for information not on plans)

	Description	Location	Size (W x H)	U-Value	SHGC
Type 1					
Type 2					
Type 3					
Type 4					
Type 5					
Type 6					
Glazed Doors					
Other					
Skylights					

8.HVAC System Preferences☐no preference

	Location	Manufacturer	Area Served	Efficiency	Heat-Pump	Gas	Duct Type
1							
2							
3							

RM Round Metal
SQ Square Metal
VF Vinyl Flex
DB Duct Board

9. Mechanical Ventilation Preferences☐no preference

On which system(s)?☐1 ☐2 ☐3 ☐separately ducted

Fresh Air Intake Type	☐Vent. Dehumidifier	☐Supply Only	☐Exhaust Only	☐Balanced
Manufacturer		Model		
Rate (CFM)		Notes		

Generalized Housing Market Identification

- Pennsylvania Average Home Size = 1814 sq. ft.

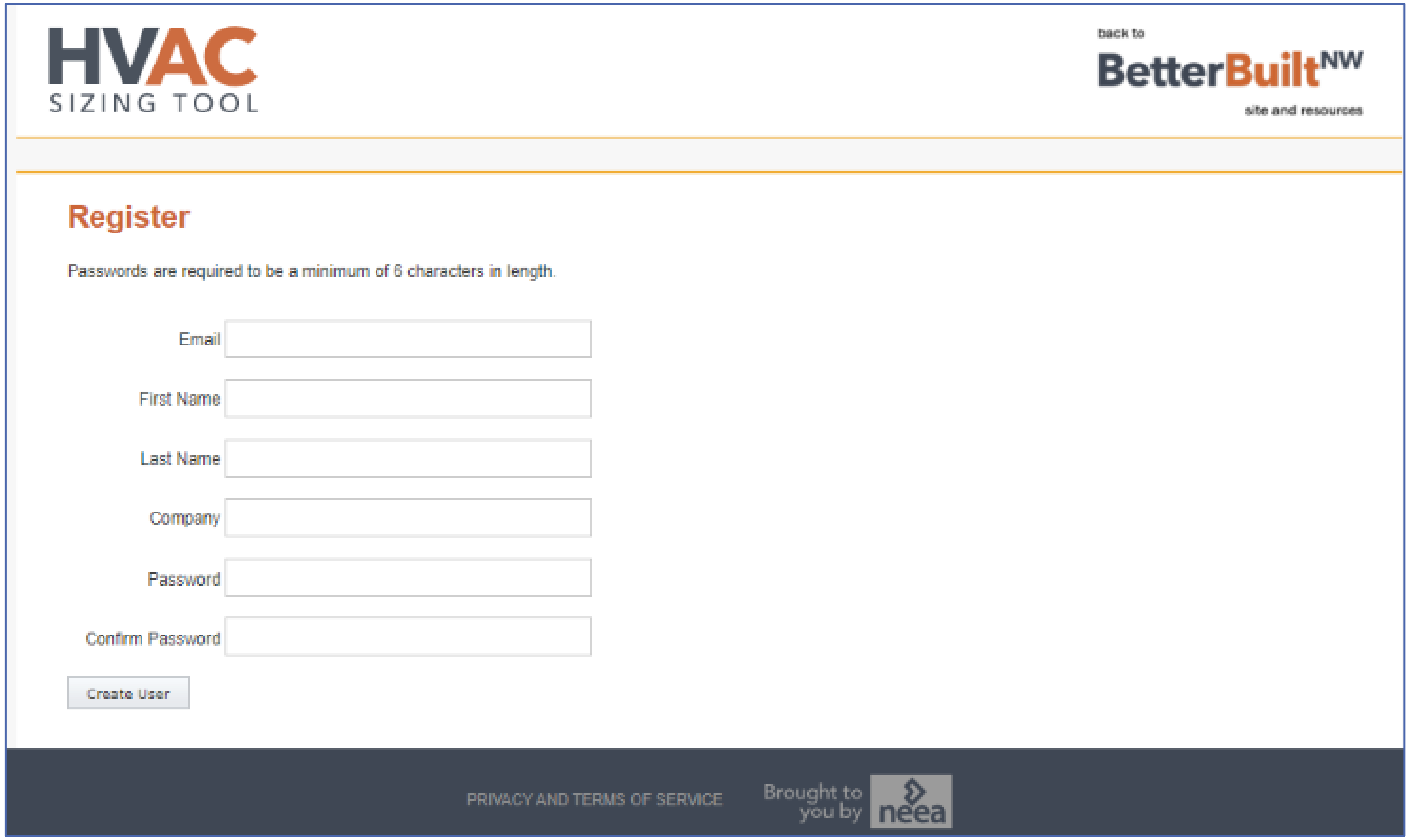
- Average Home Size in America = 2,200 sq. ft.
  - Shrinking Trend

- Pittsburg average age = 64 years old (1961)
- Harrisburg average age = 48 years old (1977)
- Philadelphia average age = 90 years (1935)

- Row houses abundant = median of 1280 square foot
  - What does this mean for Manual J???

Source: realtor.com

Free Online Sizing Tool – Using Today



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

Example Houses

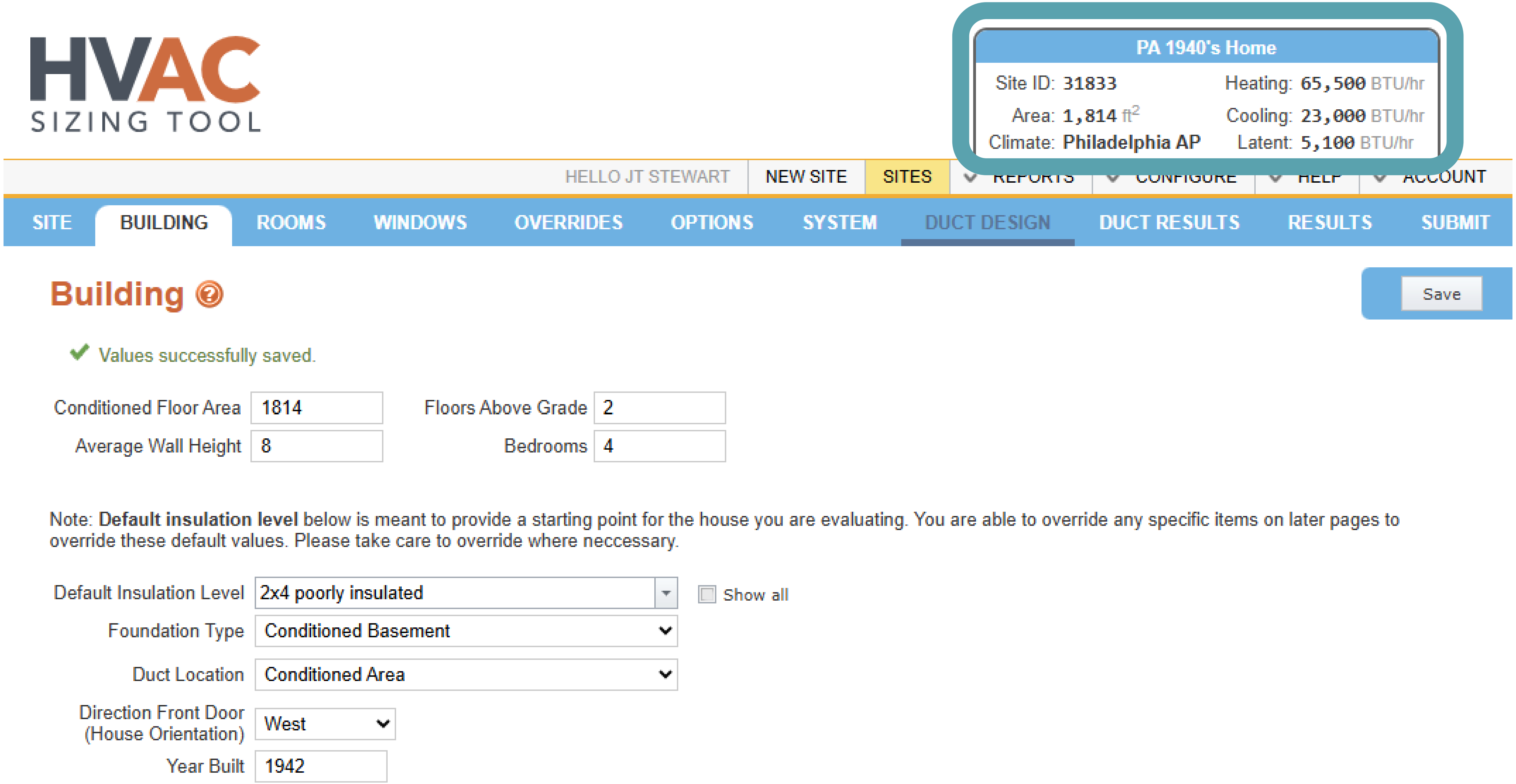
Older house (1940s)

- 1814 sq ft, 2 story home over a semi-conditioned basement.
- Heating load double the cooling load.

Newer house (2010)

- 2000 sq ft, 2 story home over a partial basement
- Heating and Cooling loads are much closer.

Example House – 1940's Home



Rule of Thumb vs Manual J for Older Home

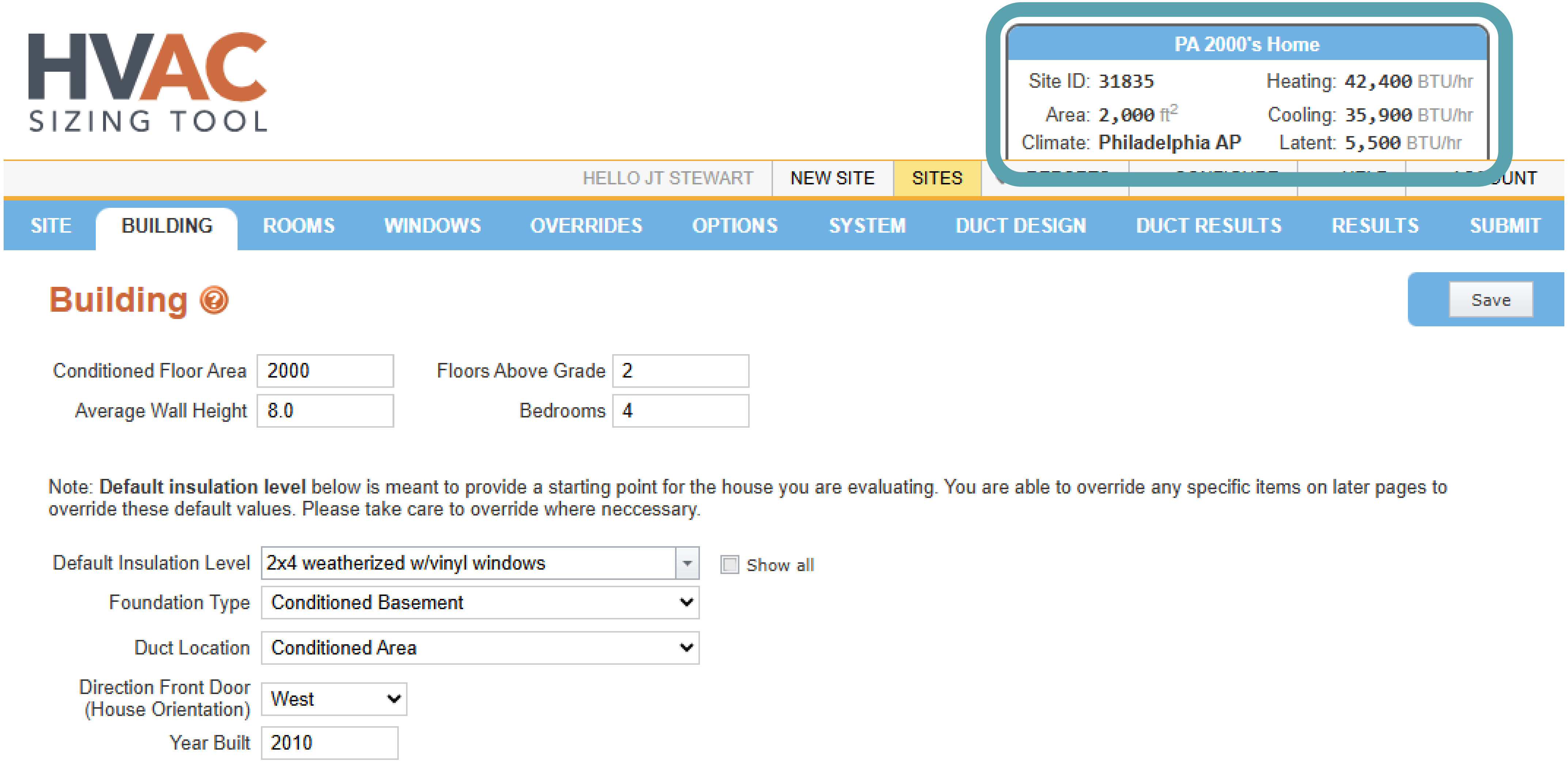
Was system oversized for heating?

- 35 btu per sq ft
- 1814 sq ft = 63,490

- Man J = 65,500

No, only off by about 3%!!

Example House – Newer Home 2010



Rule of Thumb vs Manual J for Newer Home

Was system oversized for heating?

- 35 btu per sq ft
- 2000 sq ft = 70,000 btu's

- Man J = 42,400 btu's

YES, almost doubled!

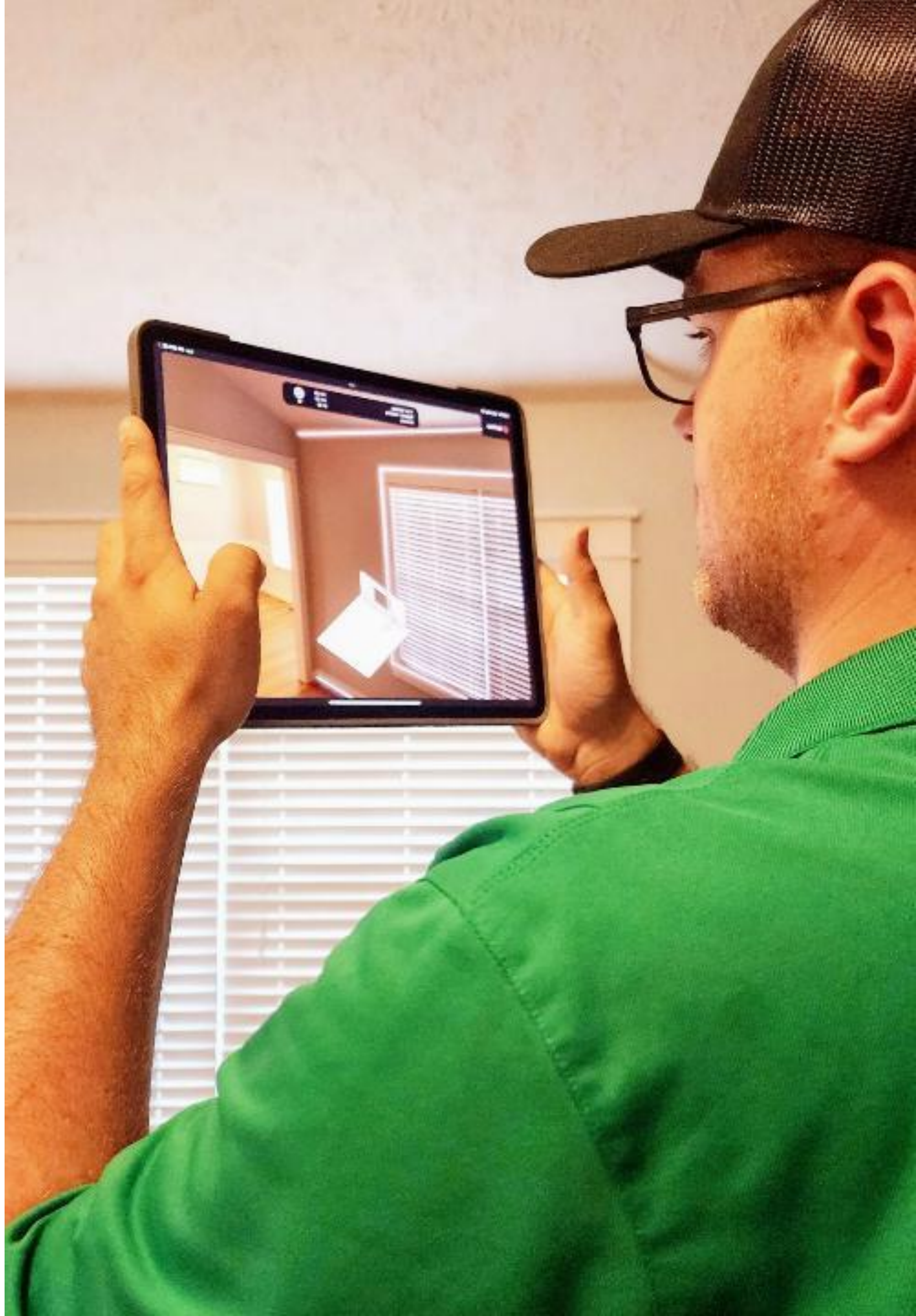
New solutions to make high quality load calculations easier

Tablet-based room scanning software (LiDAR)

- Amply
- ConduitTech
- CoolCalc
- **MORE TO COME!**

Online tools

- NEEP ccASHP for Heating tool



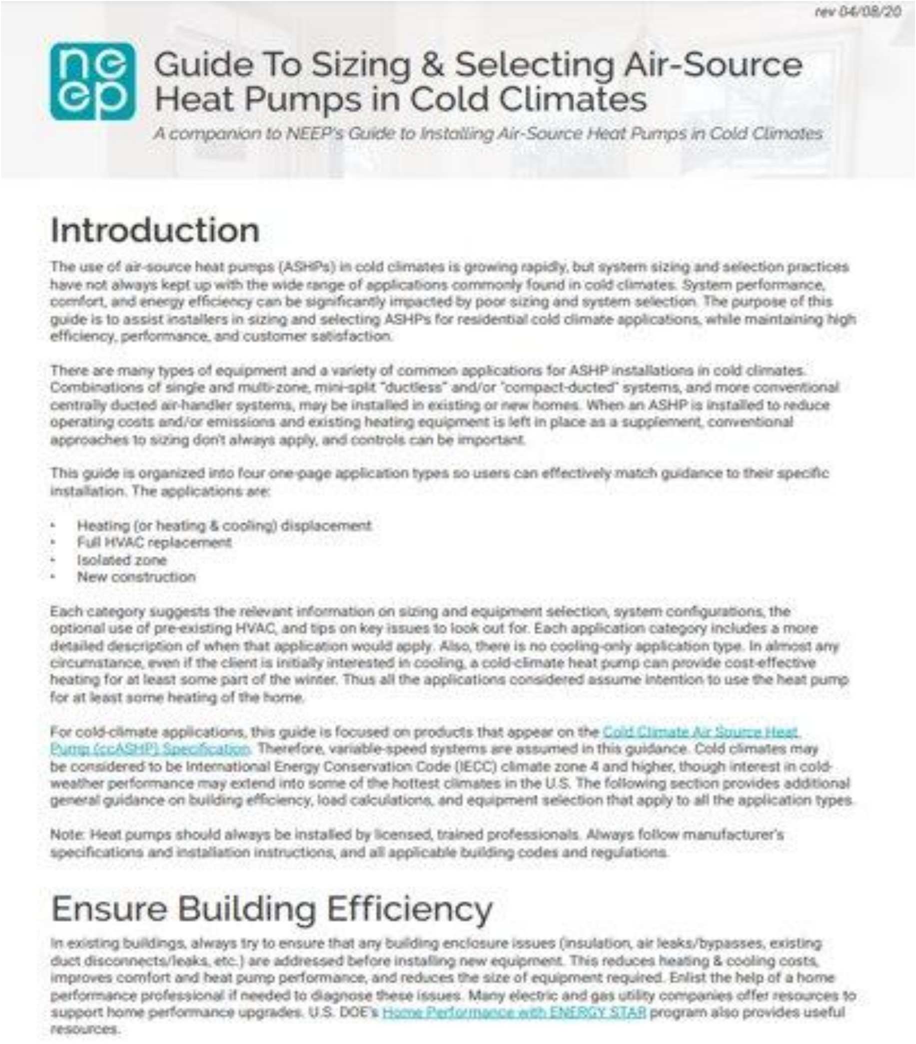
Sizing Guidance Resources

Sizing tools:

- ACCA Manual S
- Manufacturer sizing and selection tools
- NEEP Cold Climate Product List and NEW Sizing Tool

Resources

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


rev 04/08/20

neep

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

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

Introduction

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

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

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

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

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

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

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

Ensure Building Efficiency

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

Right Sizing Journey

1

Identify homes loads.
Identify resident wants and needs.

2

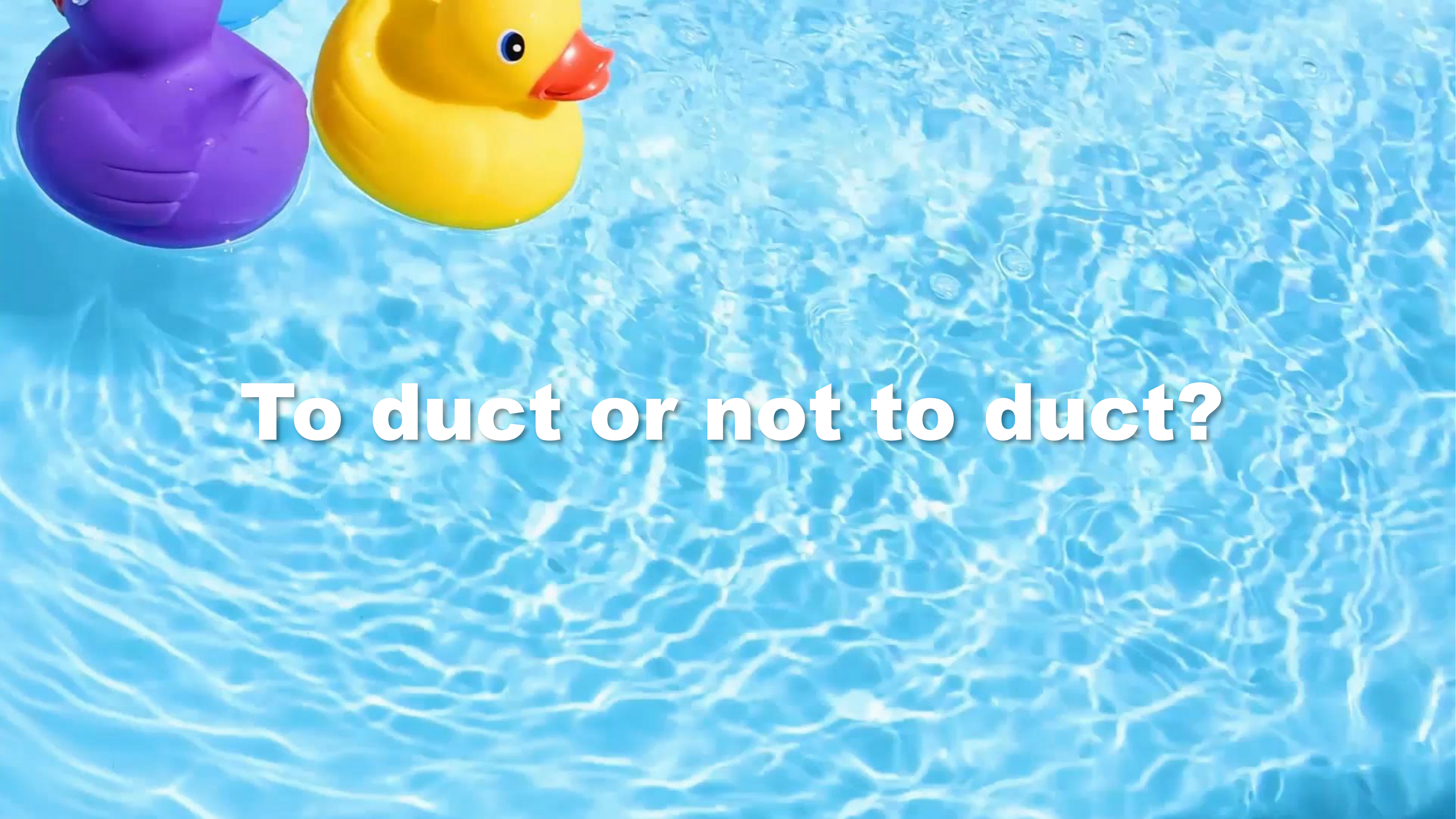
Recognize applications and limitations.
Identify fuel types.

3

Evaluate equipment that can meet goals.
Determine how far residents wish to go.

4

Install properly.
Educate residents to operation.
Set controls.


To duct or not to duct?

Open question poll

With your states average age of homes and market, what are you seeing most of?

- Boilers?
- Electric Baseboard? (eww)
- Ducted furnaces
  - Propane/natural gas?
- Hydronic retrofits?
- A/Cs in most houses
  - Ducted?

Non-Ducted Air Source Heat Pumps

Customer need: Increase comfort, reduce costs

1:1 Mini-Split Units

- Excellent for open spaces
- No thermal loss to duct work or unconditioned space

1:2-4 Multi-head Units

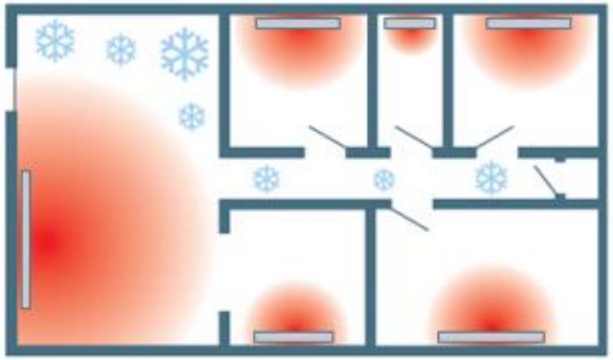
- Not optimal for highest efficiency
- Helpful under limited conditions

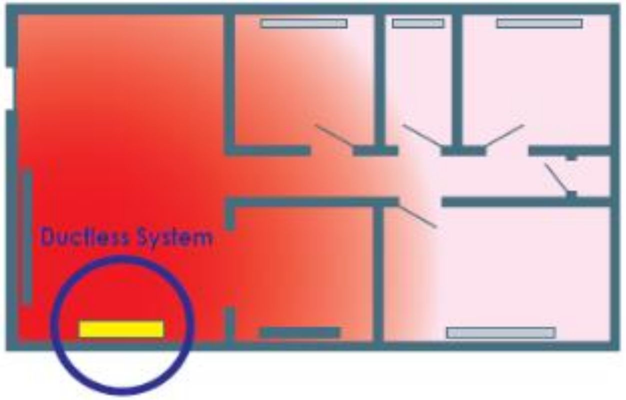
PTHP

- Fits in an existing PTAC sleeve

Best Uses

- Small weatherized homes
- Uncomfortable rooms
- Seasonal use cabins

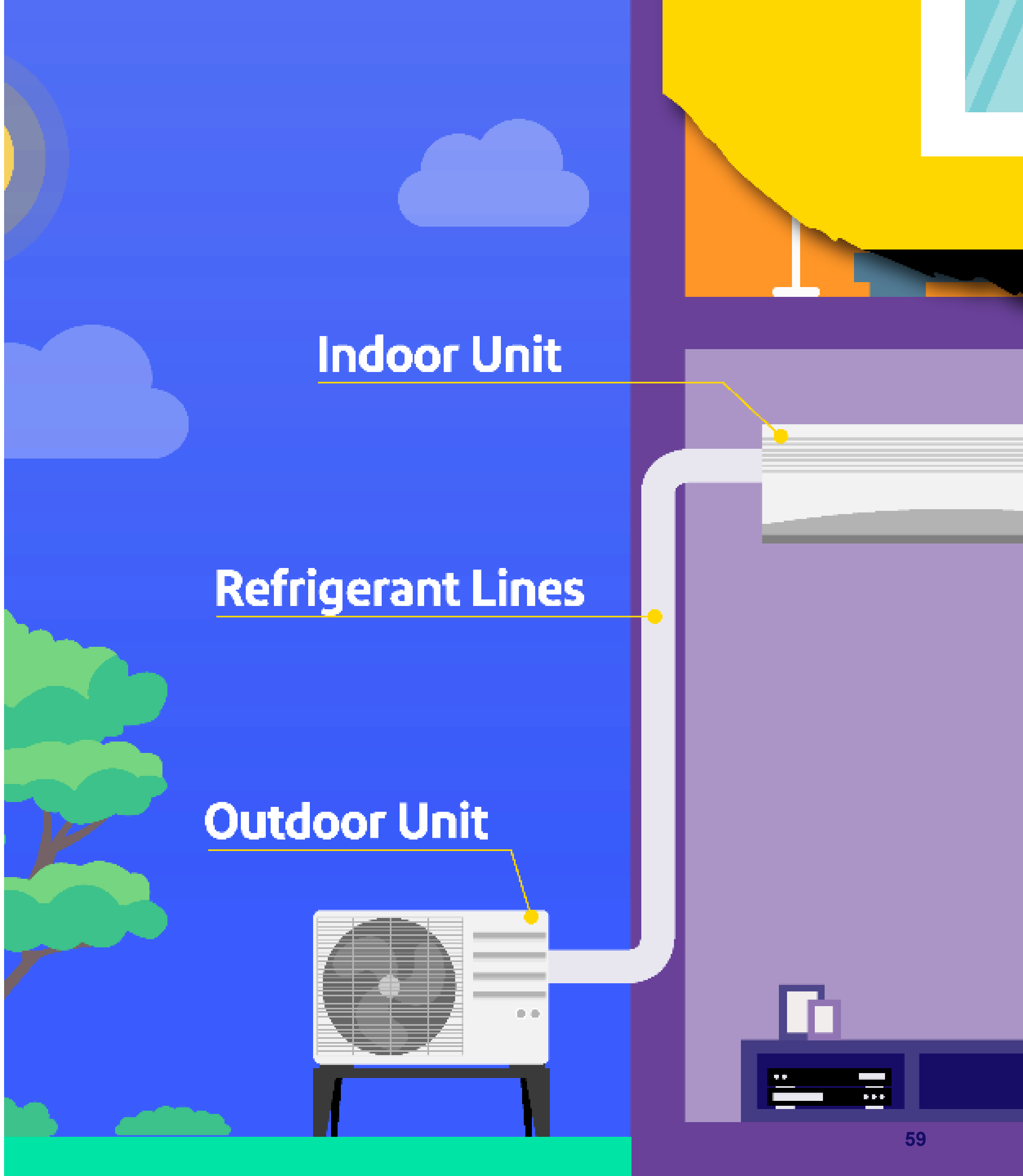




Ductless systems with non-connected back-up

These systems consist mini- / multi-split and a non-connected heat source:

- Electric base board
- Boiler
- Wall furnace



Result of Adding Ductless Mini-Splits

Centrally-Ducted Air Source Heat Pumps

- **Standalone: air source heat pump + new coil, existing furnace kept.**
  - Caution: there are only a few products that meet eligibility for rebates in this category
  - The eligible models in this category are inverter based
- **Single Stage**
- **Two/Three Stage**
- **Variable Capacity (Inverter Compressors)**
  - May or may not be cold climate rated by NEEP
  - Can include cross over solutions from Bryant/Carrier and Mitsubishi

Why is it important to understand ductwork implications?

Increased fan energy use for:

- ECMs when encountering resistance (static pressure)
- Constant torque motors

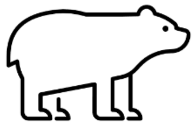
Decreased airflow for:

- PSC motors when encountering resistance (static pressure)
- Constant torque motors

Capable of delivering the air where it needs to go!

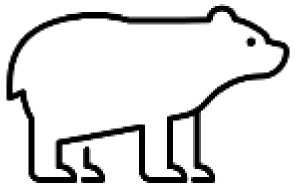
DON'T FORGET THE "V" IN HVAC – OR YOU'LL BE A HAC(K)!

Why sizing matters



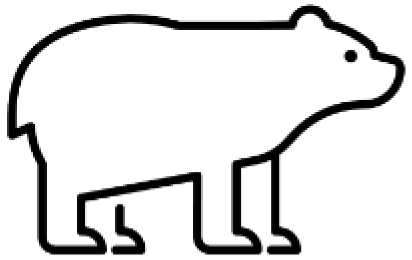
Run times matter: **longer run times are better for heat pumps**

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

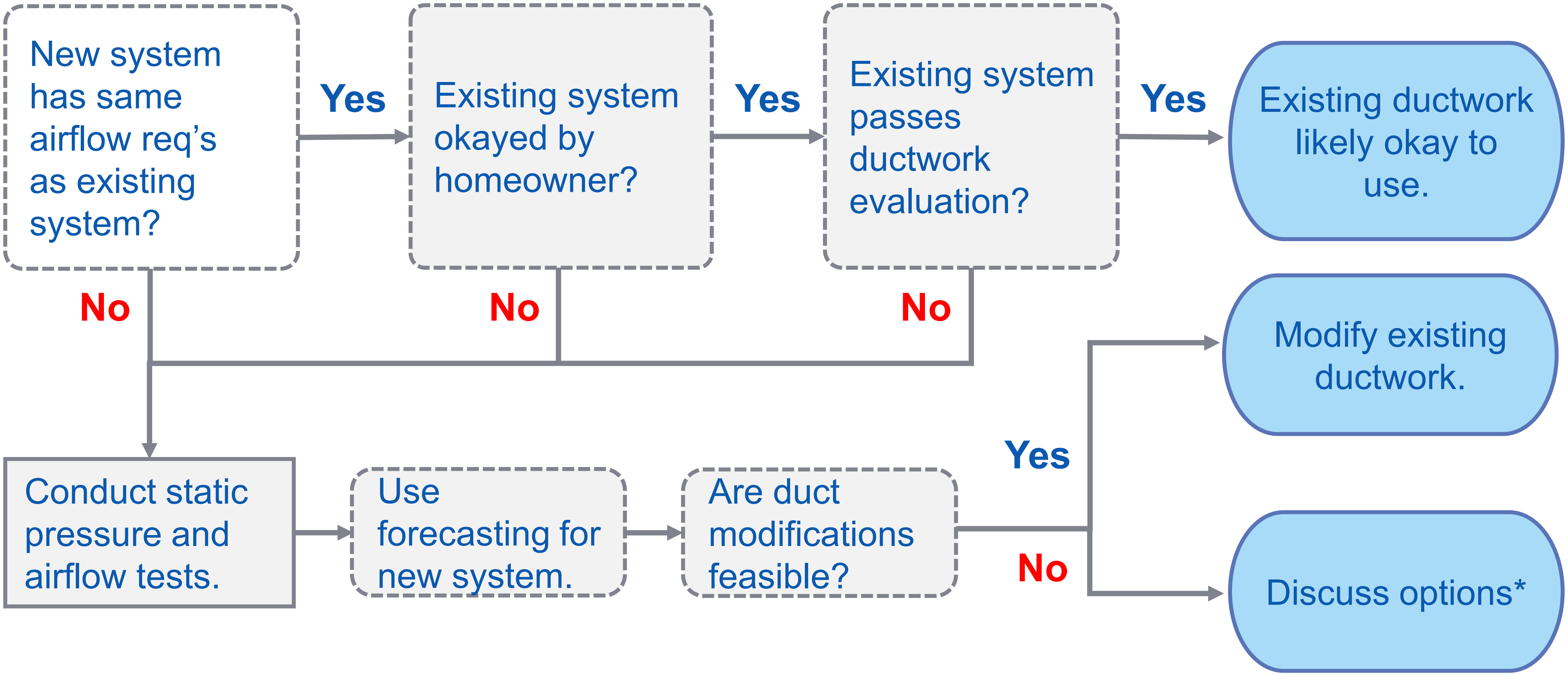


Larger compressors and fans may be noisier and require larger electrical circuits

Oversized systems may struggle with existing ductwork



Decision tree for existing ductwork



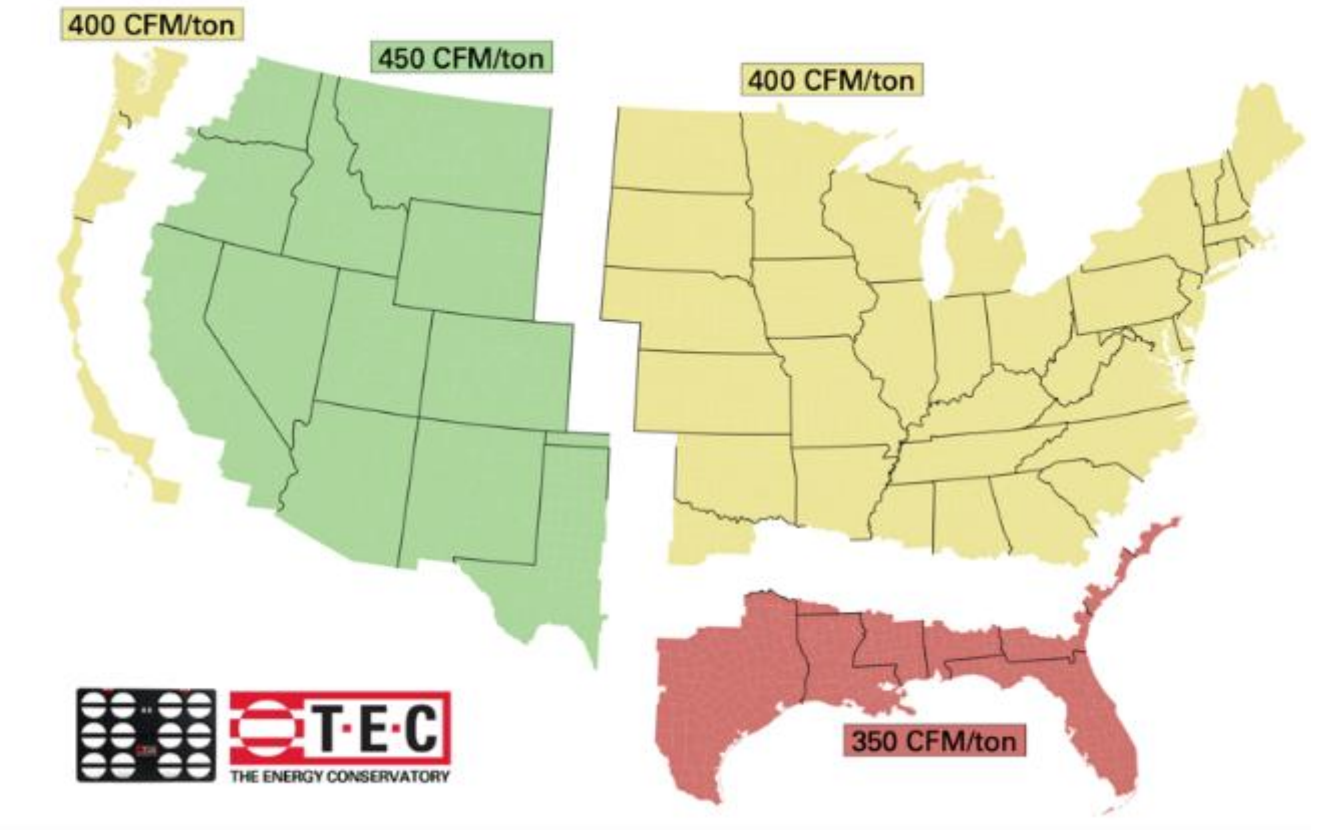
Air conditioner air flow

Single and Two speed ACs

- 400 - 450 CFM per Ton

Variable Capacity Heat Pumps

- 325 – 450 CFM per Ton



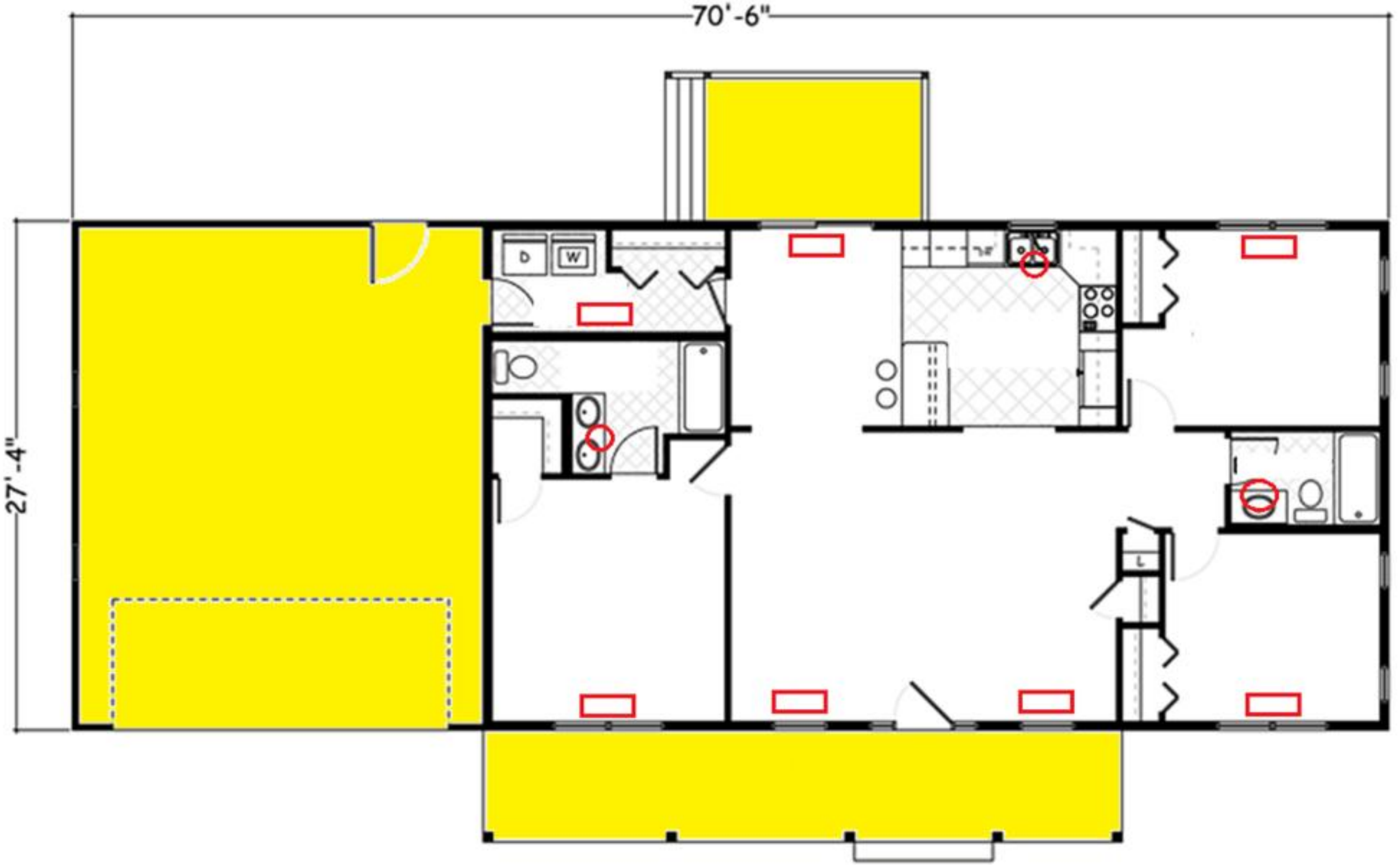
Please check manufacturer expanded performance data. Rule of thumb used for example only!

NOTE: Rule of Thumb ALERT

Evaluating Existing Ductwork

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

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

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**

Is this enough?

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

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

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.

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

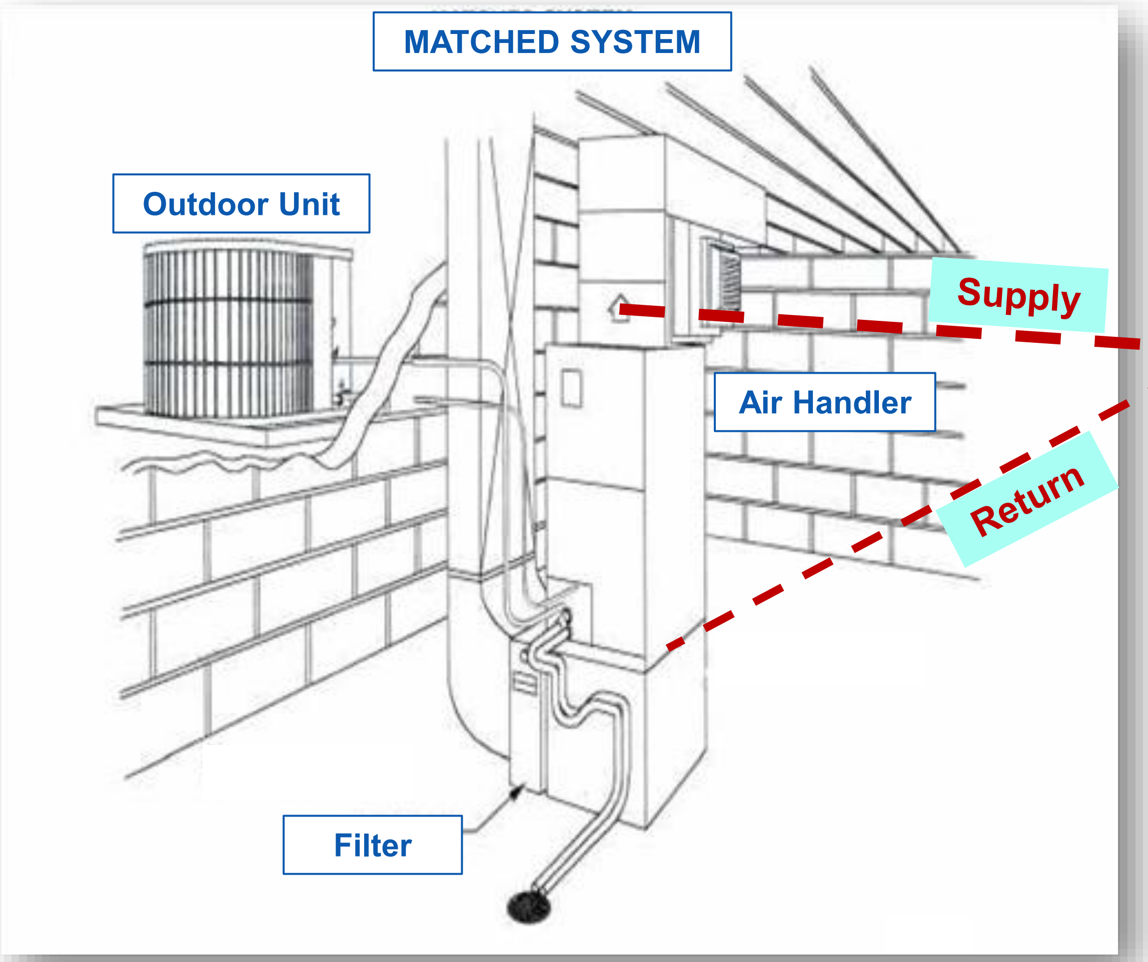
Home	Duct type	Blower type	Total Pressure (in. w.c.)	Airflow rate (CFM)	Cooling (kWh)	AHU Fans (kWh)	Total Electricity (kWh)	Heating ($\times10^6$ Btu)	Total Gas Consumption ($\times10^6$ Btu)
Chicago 3-ton AC Gas furnace 1200 CFM nominal	Flex	PSC	0.50"	1200	619	542	8108	60.95	88.88
			0.80"	964	661	531	8139	60.93	88.85
			1.10"	622	786	600	8331	63.71	91.70
		ECM	0.50"	1200	611	319	7878	61.55	89.51
			0.80"	1162	614	411	7972	60.47	88.39
			1.10"	1103	631	478	8056	60.86	88.78
	Metal	PSC	0.50"	1200	611	531	8086	59.52	87.41
			0.80"	964	656	525	8128	60.25	88.16
			1.10"	622	769	583	8300	62.17	90.12
			0.50"	1200	603	314	7861	60.10	88.02

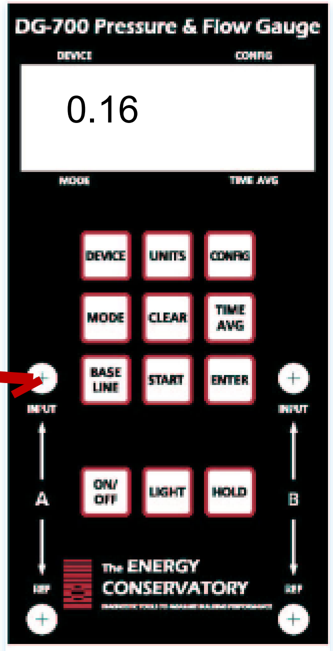
What do we do now?

- Can you add additional runs?
- Can you increase the duct size to the registers?
- Size for the **max airflow**
- Size for cooling load
- Upsize return duct size?
- Upgrade base cans and major plenum connections

Caution: When potential asbestos-containing materials are present, refer to a remediation specialist.

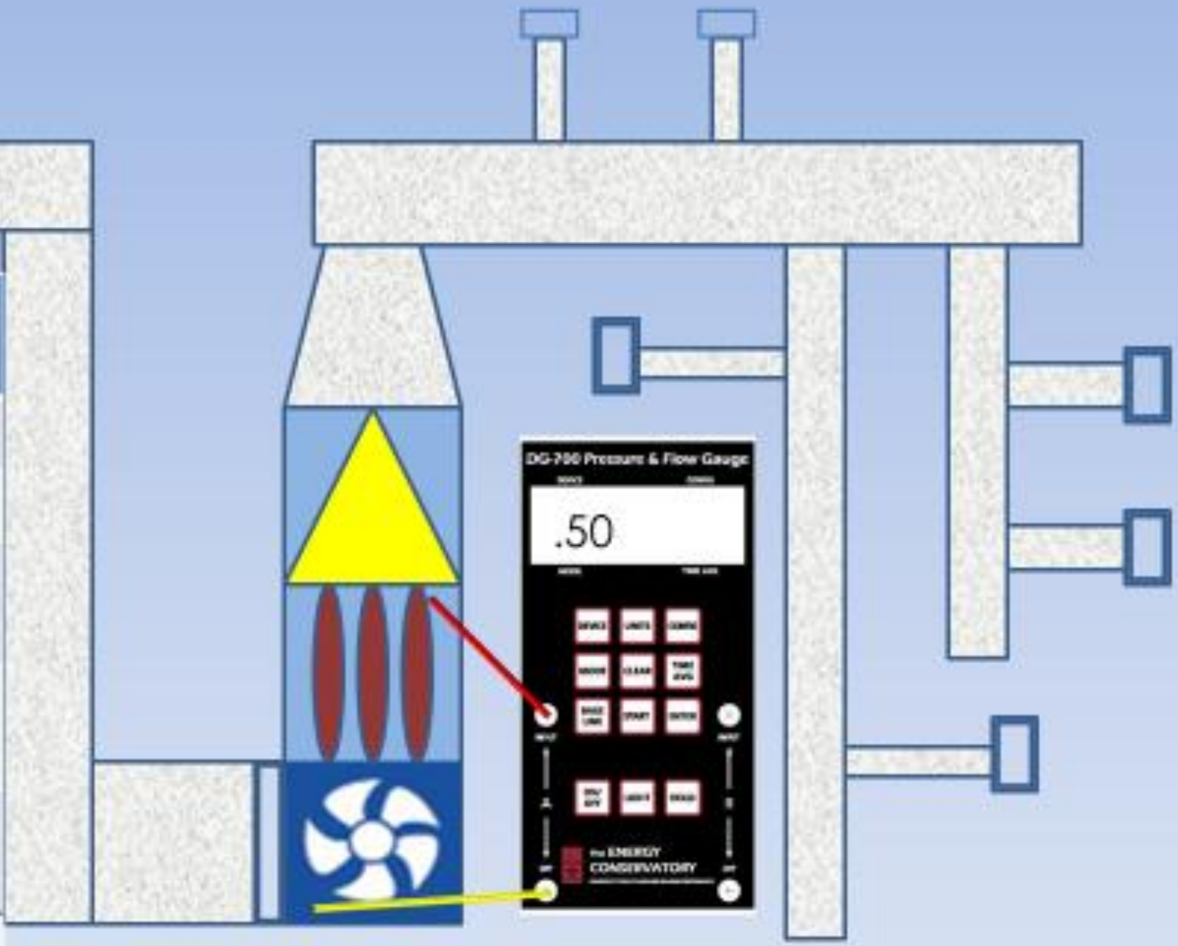
Definition:
External static pressure for heat pumps





Note: the tap in the return duct needs to be after the filter and before the air handler.

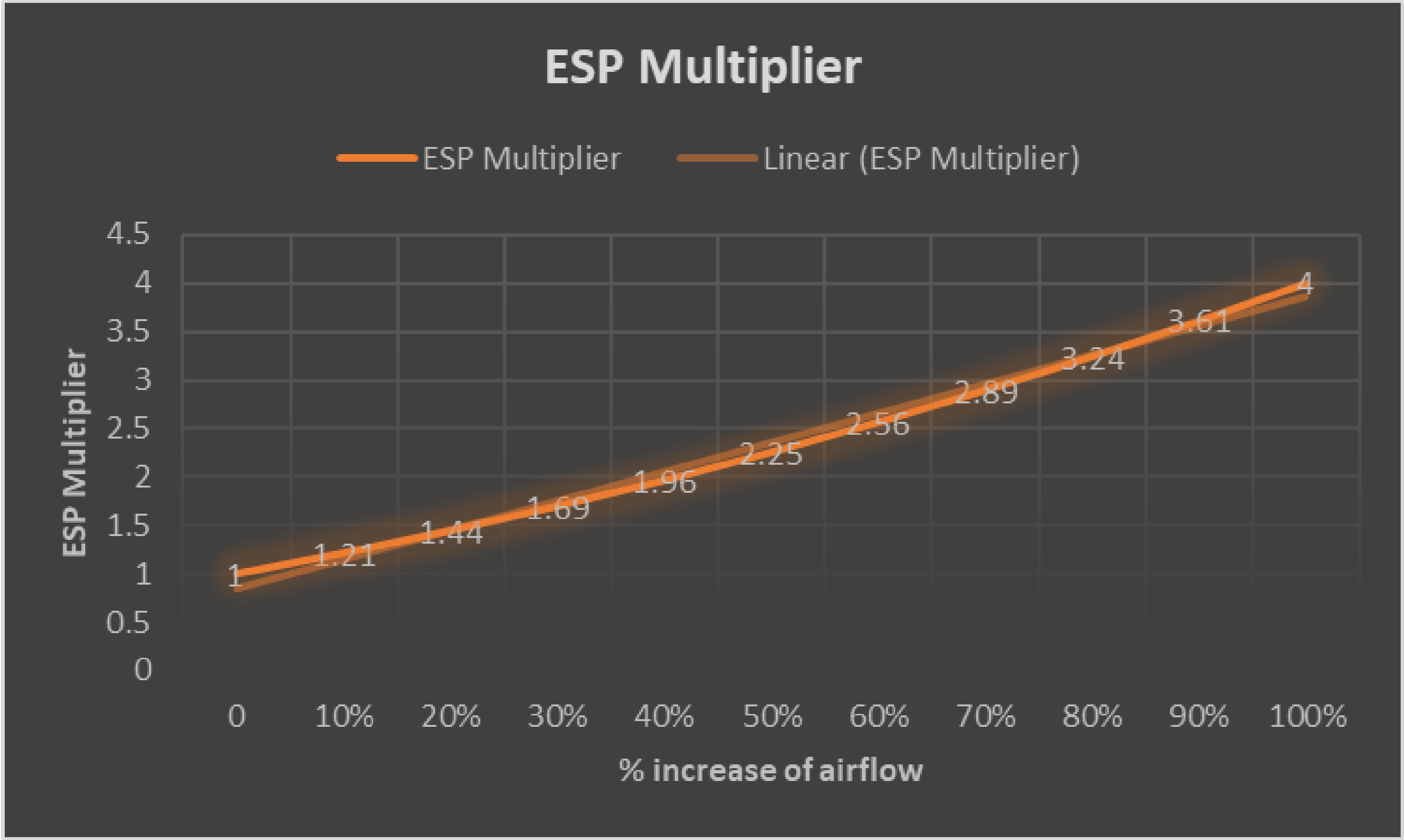
Total ESP	.50 IWC
Coil	.25
Filter	.07
Return Grille	.03
Supply Grille	.03
Total Losses	.38
Available Static Pressure	.12 IWC



The available static pressure is the amount of pressure left over to overcome the resistance of the duct system. Coils and filters have large pressure drops.

External static pressure multiplier

1. Measure TESP (total external static pressure)
2. Use a flow plate (preferred method) or onboard diagnostics if available to measure flow at high speed
3. Compare flow to projected flow needs based on sizing of heat pump (manufacturer tables)
4. Determine what the TESP should be to meet desired flow
5. Make good choices!



Special thanks to Bruce Manclark for the multiplier table!

General rules of thumb – no one manufacturer or model represented

Total external static pressures

This brand recommends not exceeding 0.65

Measure TESP that we currently have

Determine the available static pressure that is left

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

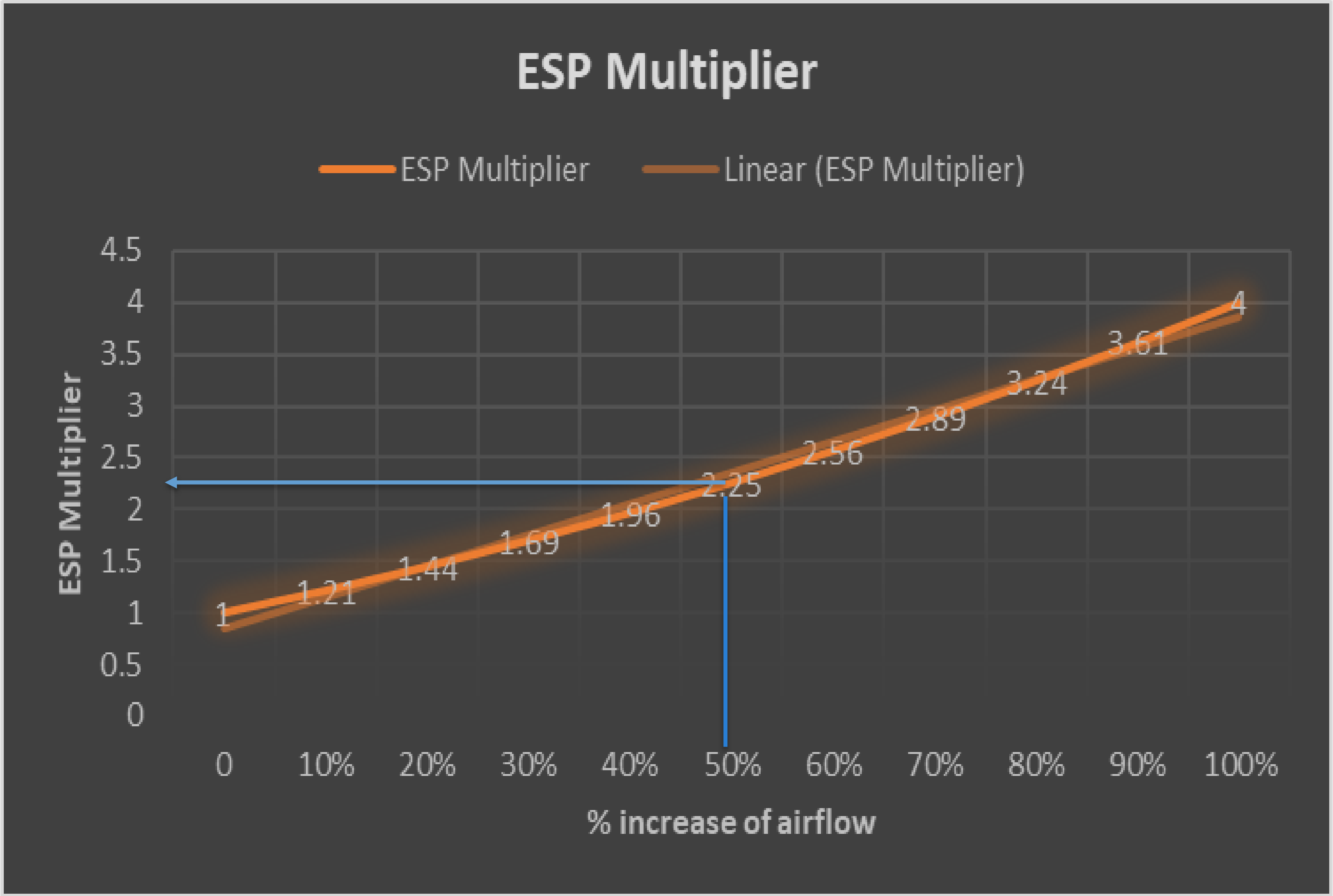
60KBTU GAS FURNACE & 2-TON AC
Sizing a NEW Heat Pump for Heating First
NEW VCHP is 3-Ton

60,000 btu Gas furnace needs 900 CFM

2-Ton AC needs 900 CFM

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

External static pressure multiplier

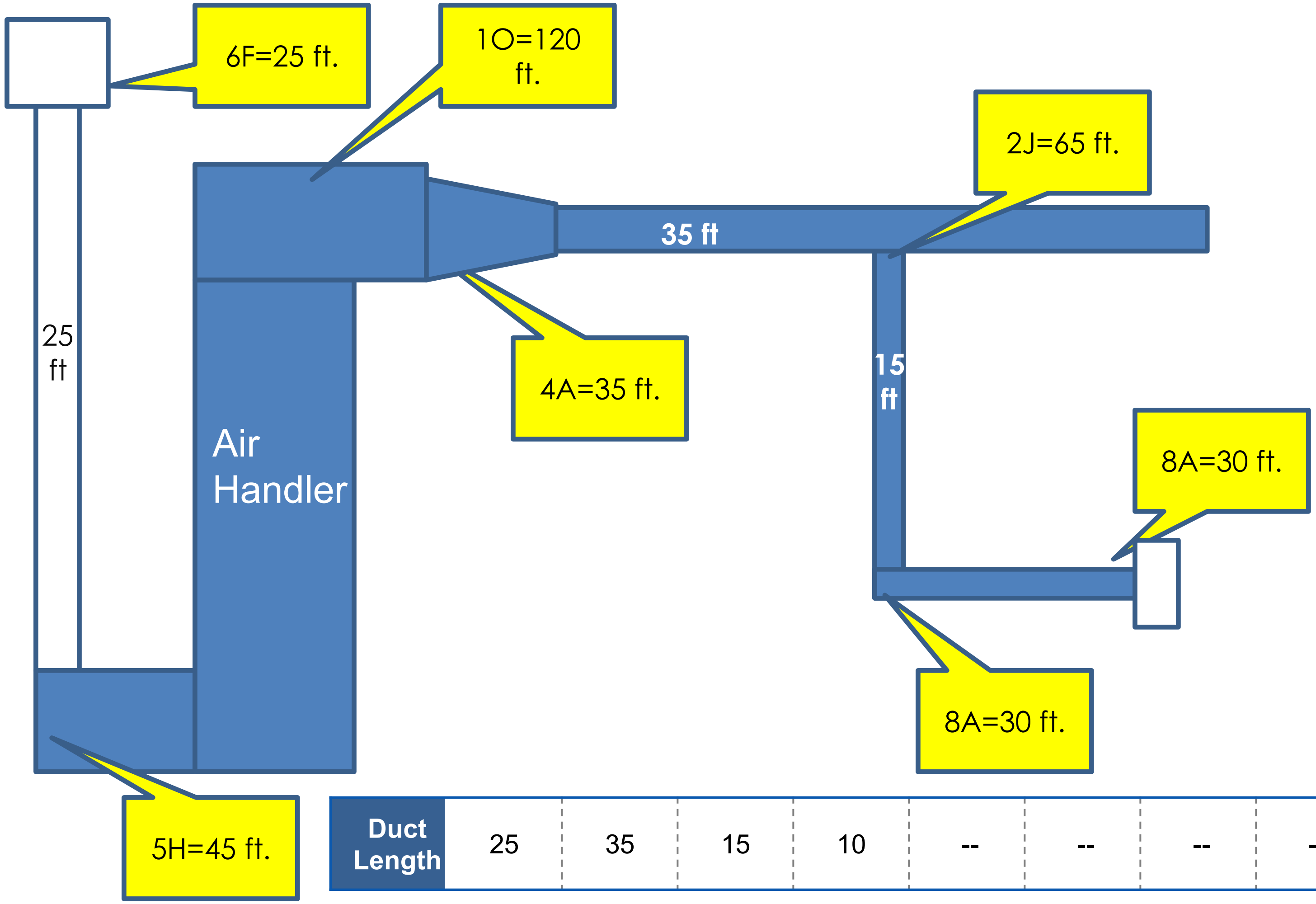


Going from 900 to 1350 cfm would be a 50% increase in flow

Static pressure would use an ESP multiplier of 2.25

So, a TESP of 0.4 would go to **1.0!**

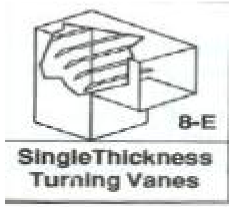
What can we do to lower this back to under 0.6?



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

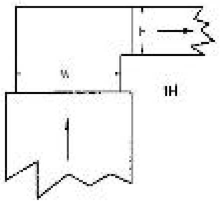
Fitting	6F	6N	5H	1O	4A	2J	8A	8A	--
EL	25	10	45	120	35	65	30	30	360
								Grand Total	445

Comparison of equivalent lengths (ELs)



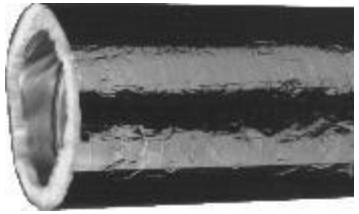
EL=10 feet

EL=20 feet

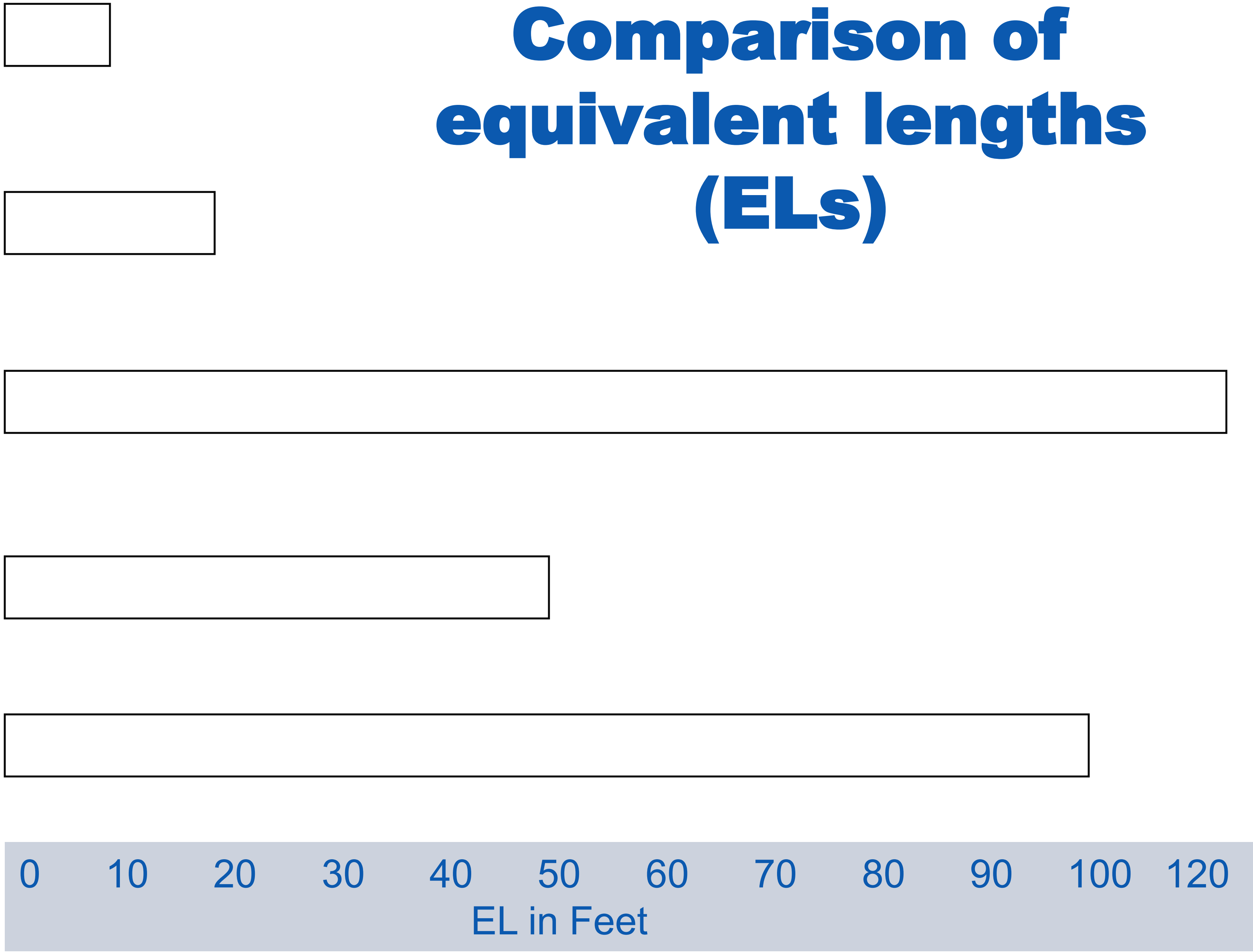


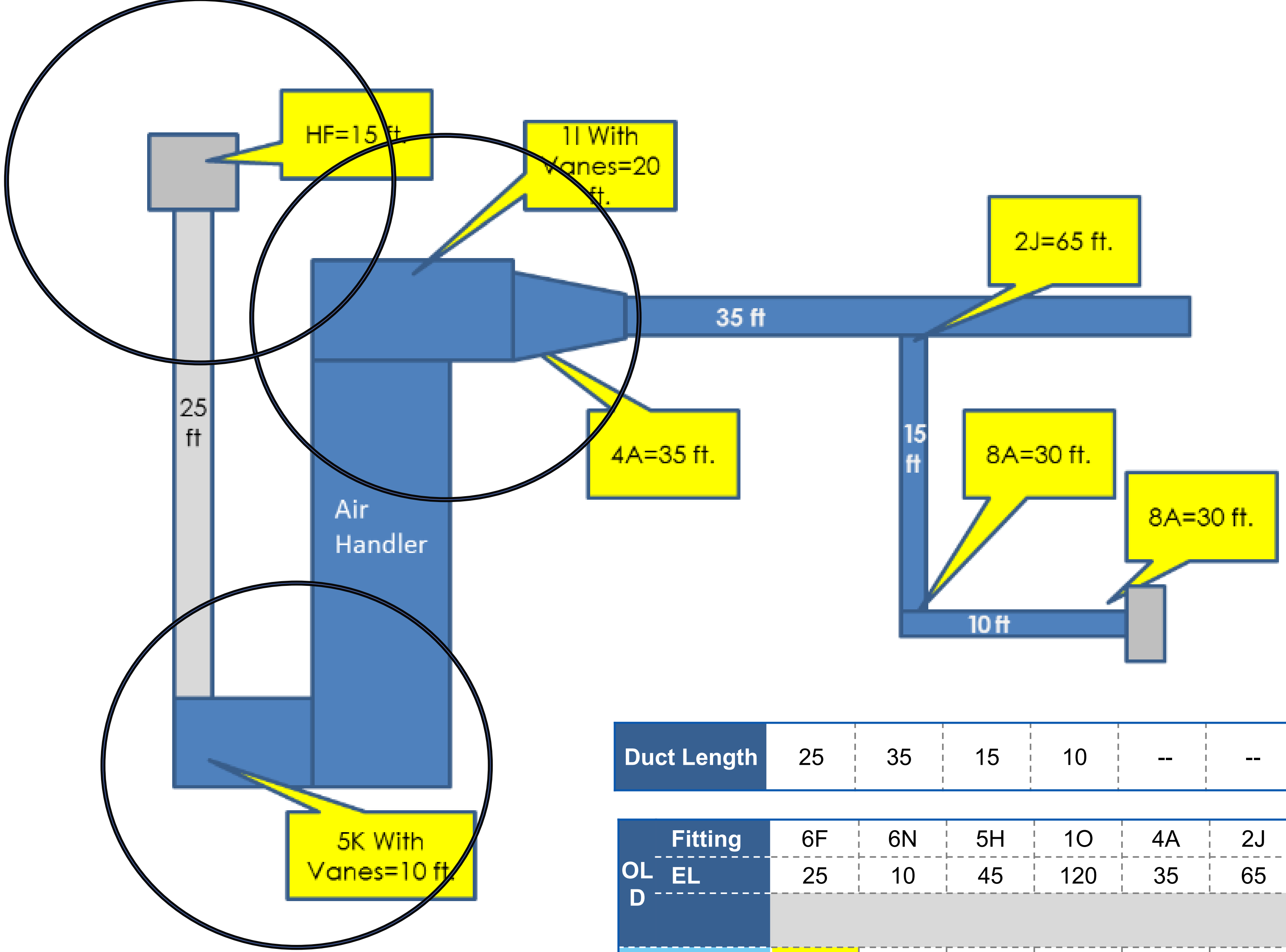
EL=120 feet

50 feet has an EL of 50 feet



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





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

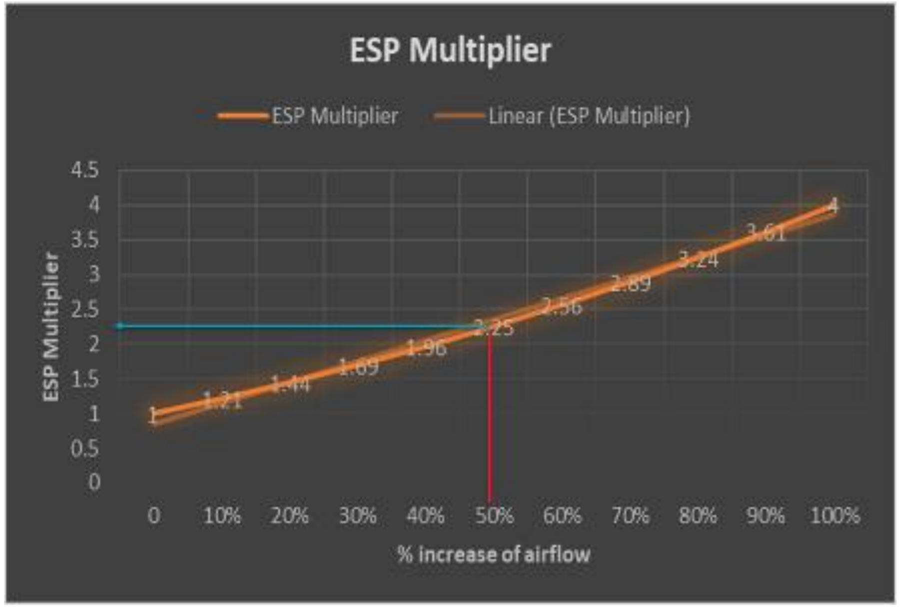
Then re-measured ESP

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



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

Success!

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

Measuring airflow

*Two models exist, modern Bluetooth and original model

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

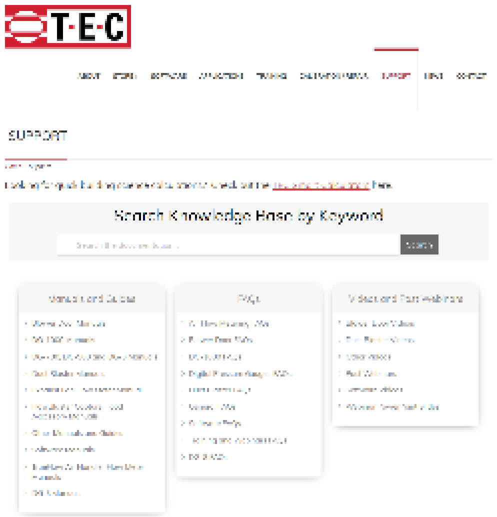
Requires upfront cost of purchase of True Flow

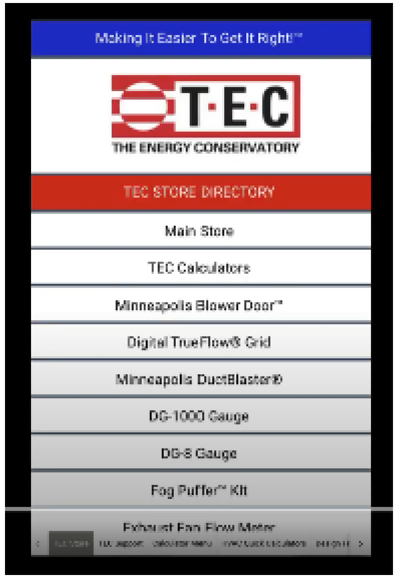
Very accurate

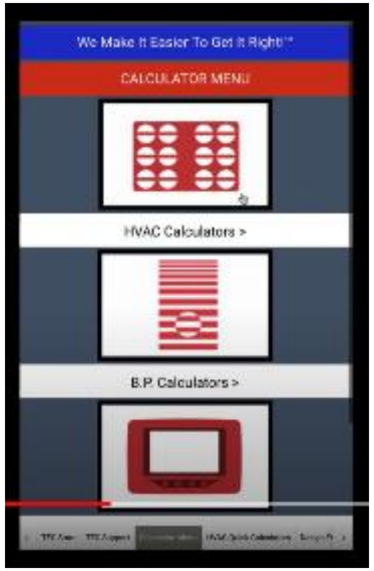
Easily fits into TEC Airflow app and measureQuick app

Aligns with Standard 310 and Standard 5

The Energy Conservatory Smart Calculator App







[TEC Smart Calculators Tutorial](#)

[TEC Demonstration Video for TESP Testing](#)

Can the existing duct system handle the airflow?

Summary

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

If not:

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

Right Sizing Journey

1

Identify homes loads.
Identify resident wants and needs.

2

Recognize applications and limitations.
Identify fuel types.

3

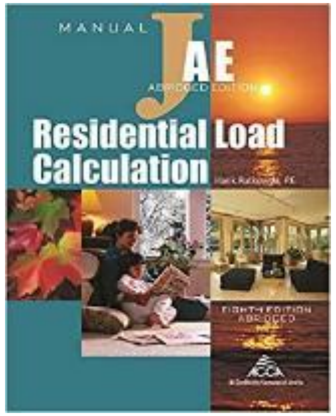
Evaluate equipment that can meet goals.
Determine how far residents wish to go.

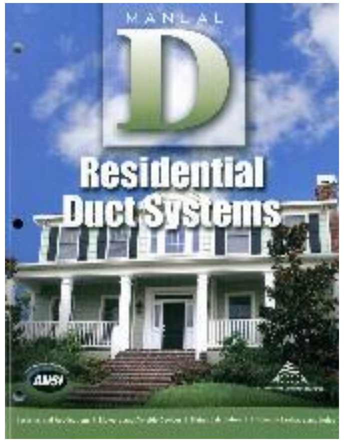
4

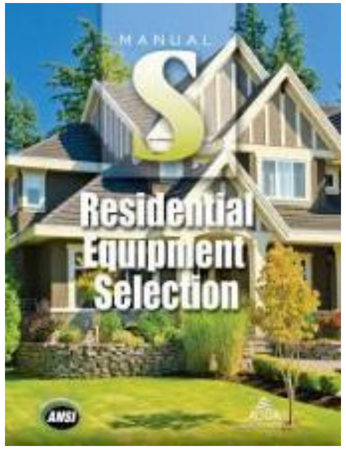
Install properly.
Educate residents to operation.
Set controls.

Challenges

- Collecting enough information for accurate load calculations
- Determining when to size for heating vs. cooling
- Distribution (ductwork) not properly designed for variable speed equipment
- Belief that heat pumps aren't a viable year-round heating technology in cold climates
- Inaccurate expectations of how heat pumps should operate, leading them to not use them/overuse them, or request unnecessary service calls
- Selecting the right heat pump for the use case
- Selecting the best control strategy for the customer and equipment
- For more resources visit: www.acca.org/standards/approved-software







Features to Help Rationalize the Best Option

Provides both heating and air conditioning

- Capacity varies with heating and cooling needs

Advanced heat pump technology

- Inverter driven compressor
- Low ambient noise
- Works well when it is cold outside

Highest efficiency

- Heating Seasonal Performance Factor (HSPF)
- Seasonal Energy Efficiency Ratio (SEER)

Definitions for Switchover Temperature / Balance Point

The balance point is a **temperature** at which switchover happens

Thermal balance point	• The outdoor temperature at which the heat pump can no longer produce the heat needed for the home. • Also called Capacity Balance point.
Economic balance point	• The outdoor temperature at which the cost to heat the home with the HP is more expensive than the back up heat cost. • Relies on the back up heat fuel cost.
Comfort balance point	• The outdoor temperature at which the homeowner experience discomfort when running the heat pump.

NEEP's Cold Climate Specification

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

- Variable capacity, residential-scale, air source heat pump. Ducted or ductless
- High rated heating efficiency (≥ 9 HSPF ductless, ≥ 10 HSPF ducted)
- High efficiency even at 5°F (COP ≥ 1.75)
- Highly rated cooling efficiency
- Capacity and efficiency data reported at multiple operating conditions

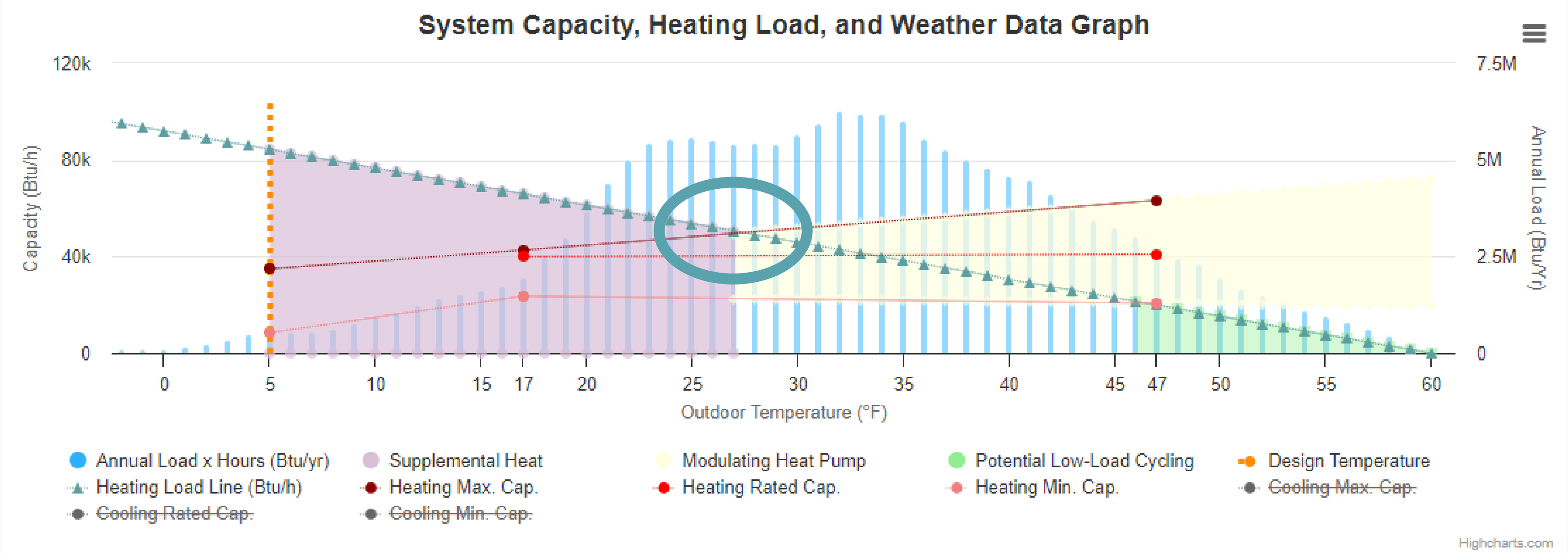
neep

- Sets and periodically updates the standard
- Maintains a qualifying product list
- Publishes the resultant engineering data

Determining the Thermal / Capacity Balance Point with the NEEP Tool

This is the best place to *guess* and check on capacity balance points your customer may not be as forgiving as this tool!

Graph Information



Product Sizing For Heating

Field Information

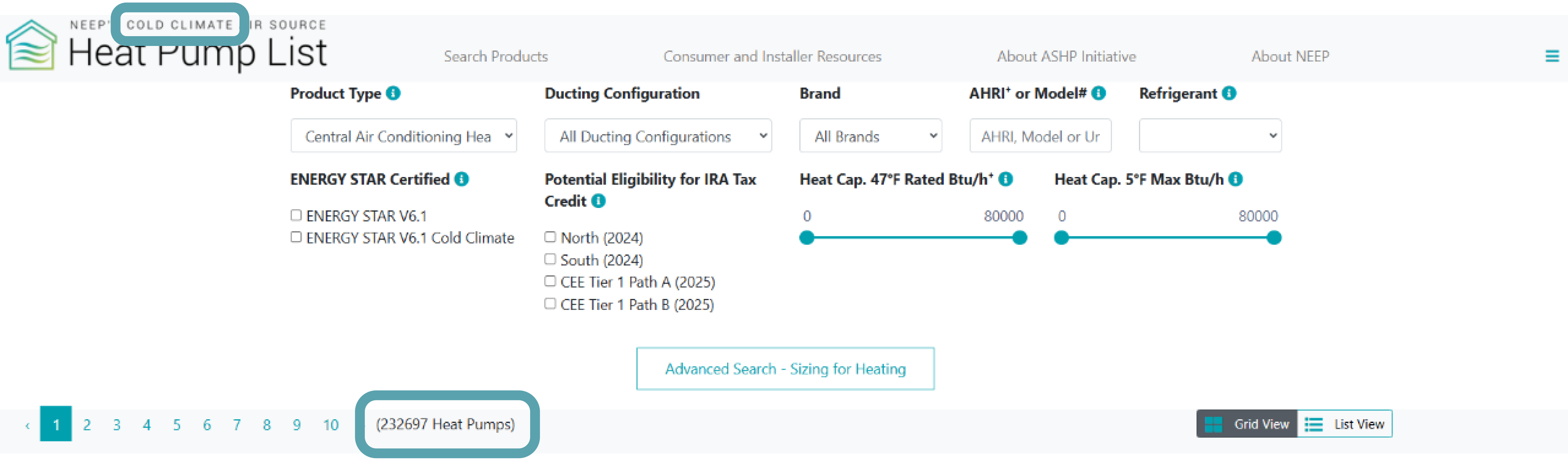
Capacity Balance Point (°F)	27
Minimum Capacity Threshold (°F)	46
Maximum Capacity at Design Temp (Btu/h)	0
Percent Design Load Served	0.0%
Annual Heating Load (MMBtu)	175.5
Percent Annual Heating Load Served	67.5%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	57.1
Hours Requiring Supplemental Heat	936
Percent Hours Requiring Supplemental Heat	16.5%
Percent Annual Load Modulating	86.9%
Percent Annual Load with Low-Load Cycling	10.5%

Technical Sizing and Customer Confidence With Cool Tools!

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


NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List
Search Products
Consumer and Installer Resources
About ASHP Initiative
About NEEP
Product Type
Central Air Conditioning Hea
Ducting Configuration
All Ducting Configurations
Brand
All Brands
AHRI+ or Model#
AHRI, Model or Ur
Refrigerant
ENERGY STAR Certified
ENERGY STAR V6.1
ENERGY STAR V6.1 Cold Climate
Potential Eligibility for IRA Tax Credit
North (2024)
South (2024)
CEE Tier 1 Path A (2025)
CEE Tier 1 Path B (2025)
Heat Cap. 47°F Rated Btu/h+
0
80000
Heat Cap. 5°F Max Btu/h
0
80000
Advanced Search - Sizing for Heating
1 2 3 4 5 6 7 8 9 10
(232697 Heat Pumps)
Grid View
List View

Product Type | **Ducting Configuration** | **Brand** | **AHRI* or Model#** | **Refrigerant**

Central Air Conditioning Hea | All Ducting Configurations | All Brands | AHRI, Model or Ur

ENERGY STAR Certified

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

Potential Eligibility for IRA Tax Credit

- North (2024)
- South (2024)
- CEE Tier 1 Path A (2025)
- CEE Tier 1 Path B (2025)

Heat Cap. 47°F Rated Btu/h*

0 — 80000

Heat Cap. 5°F Max Btu/h

0 — 80000

Return to Standard Search

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

ZipCode	Heating Design Temp. (°F)	Cooling Design Temp. (°F)
	7	95
Weather Station	**Heating Design Load (Btu/h)**	**Cooling Design Load (Btu/h)**
	25000	7500

- [x] Limit search to one result per outdoor unit

Remember our 1942 house?

PA 1940's Home

Site ID:	31833	Heating:	65,500 BTU/hr
Area:	1,814 ft^2	Cooling:	23,000 BTU/hr
Climate:	Philadelphia AP	Latent:	5,100 BTU/hr

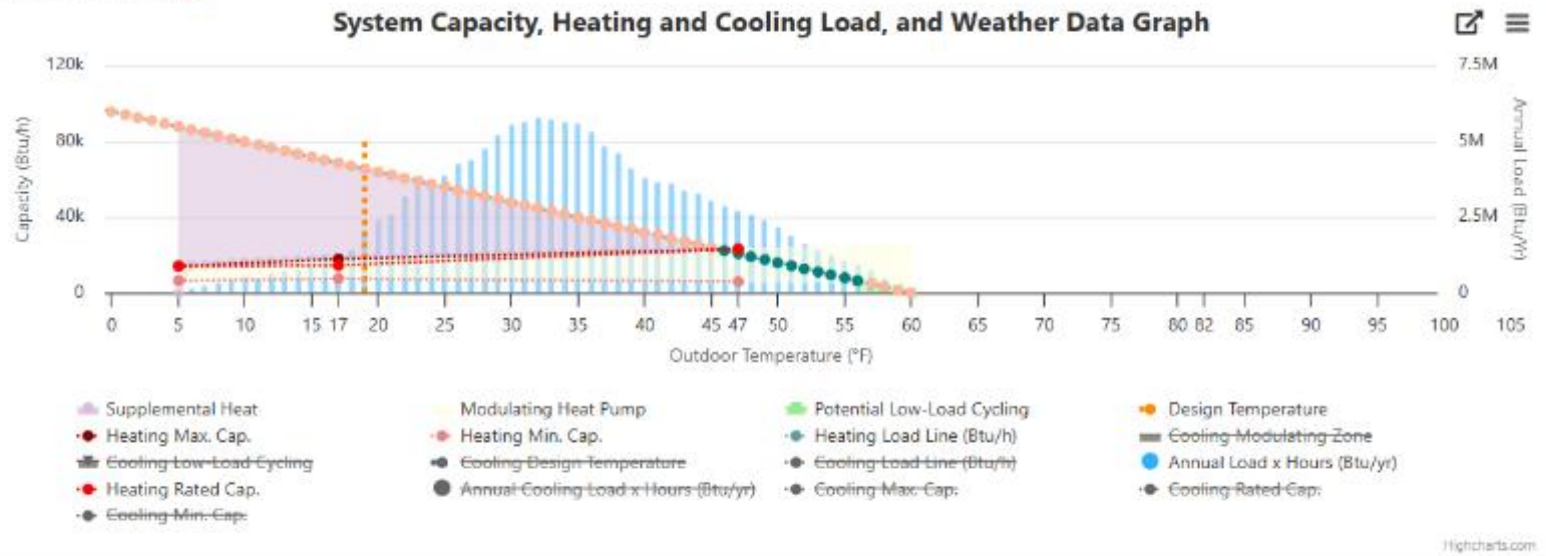
This tool is for preliminary product selection planning only. It is necessary to conduct full engineering capacity assessments that take line-length, multi-head impacts, and other factors into consideration. Use manufacturer's data and tools to finalize product sizing and selection determinations.

ZipCode	Heating Design Temp. (°F)	Cooling Design Temp. (°F)
19153	19	91
Weather Station	**Heating Design Load (Btu/h)**	**Cooling Design Load (Btu/h)**
Philadelphia Intl, Winter Design Temp: 19F	65500	23000

2-Ton Variable Speed sized to cooling

Not a notably high-efficient or top-tier system

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	46
Minimum Capacity Threshold (°F)	56
Maximum Capacity at Design Temp (Btu/h)	18,253
Percent Design Load Served	27.9%
Annual Heating Load (MMBtu)	146.7
Percent Annual Heating Load Served	58.8%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	60.5
Hours Requiring Supplemental Heat	2,912
Percent Hours Requiring Supplemental Heat	57.6%
Percent Annual Load Modulating	57.1%
Percent Annual Load with Low-Load Cycling	1.1%

- Maximum Heating Capacity (Btu/h) @5°F: **14,200**
- Rated Heating Capacity (Btu/h) @47°F⁺: **23,200**
- Rated Cooling Capacity (Btu/h) @95°F⁺: **23,200**

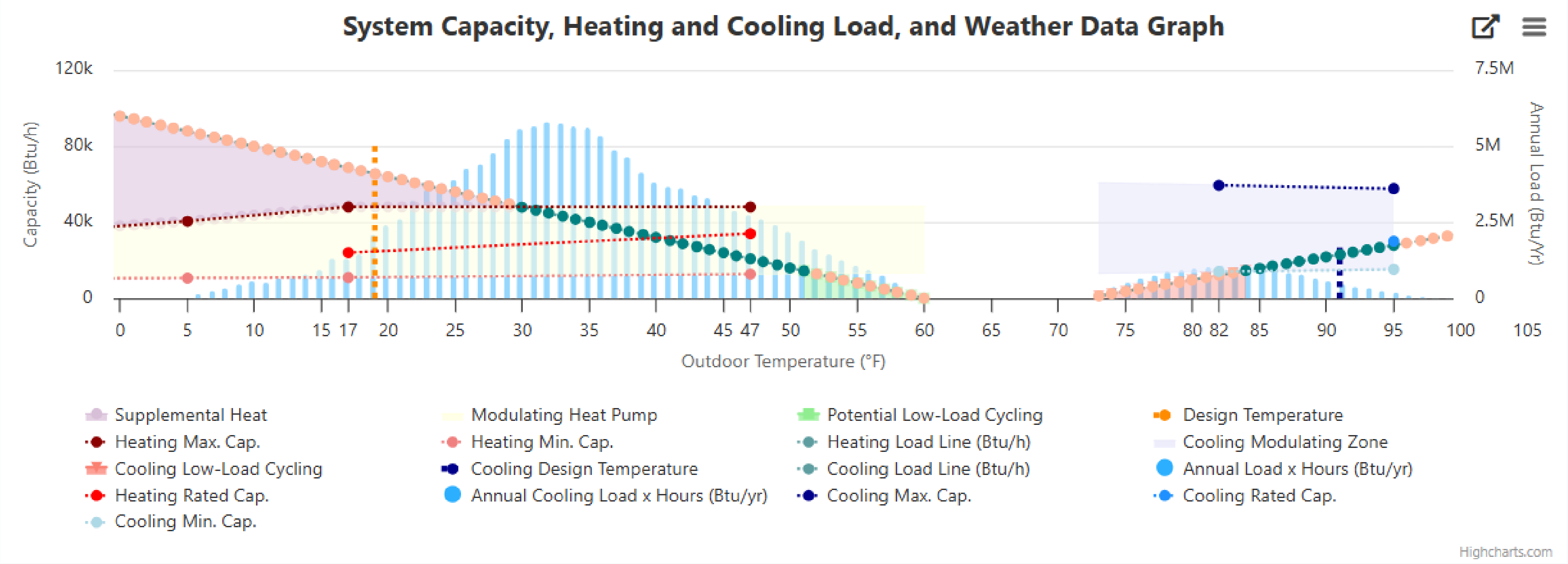
2.5 Ton High-Efficient ccASHP

Still, not the very top line for this specific brand

All-electric or ductless
*Would work well with a multi system house with a boiler, etc.

Almost no low-load cycling for cooling
Humidity?

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	30
Minimum Capacity Threshold (°F)	51
Maximum Capacity at Design Temp (Btu/h)	48,000
Percent Design Load Served	73.3%
Annual Heating Load (MMBtu)	146.7
Percent Annual Heating Load Served	72.2%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	40.7
Hours Requiring Supplemental Heat	854
Percent Hours Requiring Supplemental Heat	16.9%
Percent Annual Load Modulating	65.5%
Percent Annual Load with Low-Load Cycling	5.4%

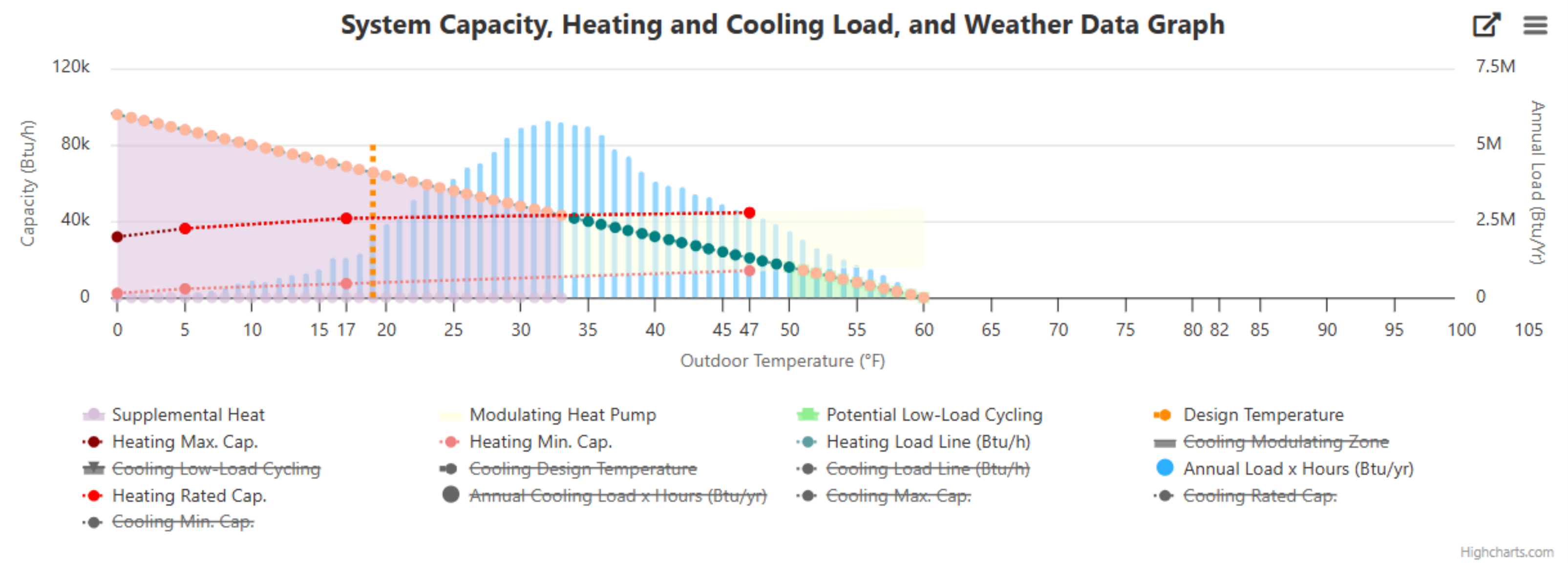
- Maximum Heating Capacity (Btu/h) @5°F: **40,500**
- Rated Heating Capacity (Btu/h) @47°F*: **34,000**
- Rated Cooling Capacity (Btu/h) @95°F*: **30,000**

3-ton VS ASHP replacement of a 2 ton centrally ducted

Dual fuel – Set lock-out at capacity balance point

For propane users – that's over 50% reduction in propane site usage for heating

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	33
Minimum Capacity Threshold (°F)	50
Maximum Capacity at Design Temp (Btu/h)	41,700
Percent Design Load Served	0.0%
Annual Heating Load (MMBtu)	146.7
Percent Annual Heating Load Served	54.4%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	67.0
Hours Requiring Supplemental Heat	1,222
Percent Hours Requiring Supplemental Heat	24.2%
Percent Annual Load Modulating	91.8%
Percent Annual Load with Low-Load Cycling	6.7%

Click here for Optional Settings

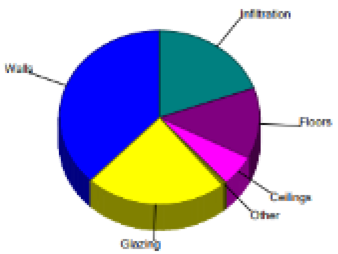
☑ Optional: Apply Compressor Lock-Out Temperature

33

Weatherization And Heat Pumps?

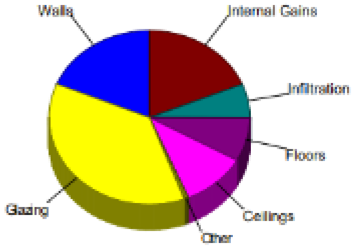
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	10.2	19387	37.9
Glazing	37.9	11751	23.0
Doors	17.3	363	0.7
Ceilings	3.3	2972	5.8
Floors	7.4	6721	13.1
Infiltration	6.7	9978	19.5
Ducts		0	0
Piping		0	0
Humidification		0	0
Ventilation		0	0
Adjustments		0	
Total		**51171**	**100.0**



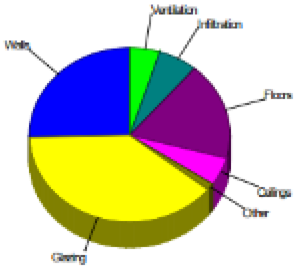
Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	2.3	4312	18.7
Glazing	27.5	8515	36.9
Doors	8.0	168	0.7
Ceilings	2.7	2422	10.5
Floors	2.1	1880	8.1
Infiltration	1.0	1450	6.3
Ducts		0	0
Ventilation		0	0
Internal gains		4320	18.7
Blower		0	0
Adjustments		0	
Total		**23066**	**100.0**



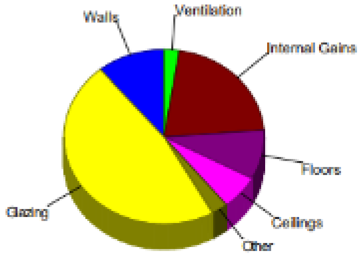
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	5.0	9419	25.4
Glazing	46.5	14431	38.9
Doors	11.3	475	1.3
Ceilings	2.1	1941	5.2
Floors	7.4	6721	18.1
Infiltration	1.6	2332	6.3
Ducts		0	0
Piping		0	0
Humidification		0	0
Ventilation		1807	4.9
Adjustments		0	
Total		**37125**	**100.0**



Cooling

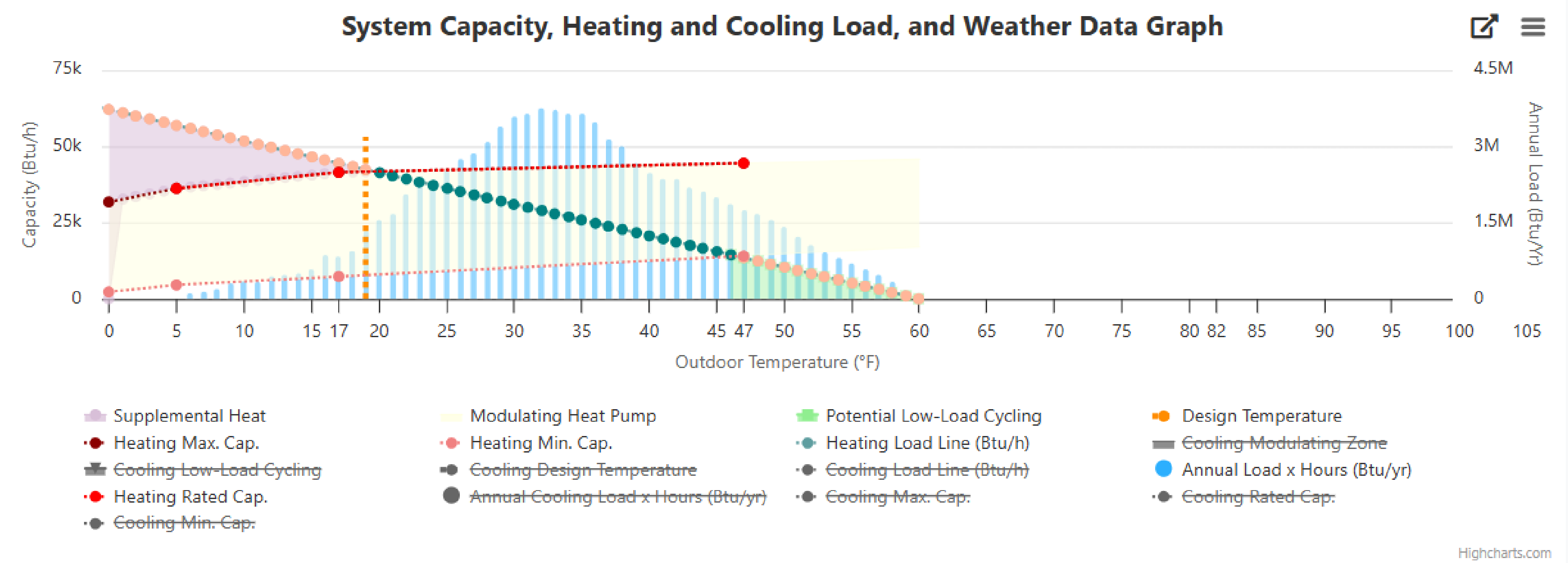
Component	Btuh/ft²	Btuh	% of load
Walls	1.2	2229	10.9
Glazing	31.0	9597	47.1
Doors	5.2	219	1.1
Ceilings	1.4	1290	6.3
Floors	2.1	1880	9.2
Infiltration	0.2	326	1.6
Ducts		0	0
Ventilation		505	2.5
Internal gains		4320	21.2
Blower		0	0
Adjustments		0	
Total		**20366**	**100.0**



Same 3-ton modeled for older house as a/c replacement

May not need duct-work adjustments, as the existing system may already be a 3 ton!

Graph Information



Product Sizing For Heating

View Oversizing Effects

Definition/Use Cases

Capacity Balance Point (°F)	20
Minimum Capacity Threshold (°F)	46
Maximum Capacity at Design Temp (Btu/h)	41,700
Percent Design Load Served	98.3%
Annual Heating Load (MMBtu)	95.0
Percent Annual Heating Load Served	93.0%

Definition/Use Cases

Annual Btu's Covered by Supplemental Heat (MMBtu)	6.6
Hours Requiring Supplemental Heat	164
Percent Hours Requiring Supplemental Heat	3.2%
Percent Annual Load Modulating	77.5%
Percent Annual Load with Low-Load Cycling	13.5%

PA 2000's Home

Site ID:	31835	Heating:	42,400 BTU/hr
Area:	2,000 ft²	Cooling:	35,900 BTU/hr
Climate:	Philadelphia AP	Latent:	5,500 BTU/hr

Typical Switchover Temperatures by Application

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

What is COP?

- Coefficient of Performance is the measure of a heat pumps efficiency.
  - Higher COP = Better Performance
- Consider the similarity of how we can educate homeowners like we do with AFUE
  - If a furnace is 96% efficient, whats the dollar *usage* efficiency?
  - If a heat pump has a **rated** COP of 2.7, whats the dollar *invested* efficiency?
- This is a moving target due to ambient temp. How do we know when to switch?

Economic Switchover Temperature

Easy, it's just math!

It is a simple math problem The easiest way to solve it is to find your break-even COP and then look at your heat pump publications to see what temperature that occurs at. You can calculate your break-even COP by:

BECOP = (E x C x e) / G where BECOP is your break-even COP

- E is $/kWh (Take your power bill and divide by kWh = 0.132 average in Chicago)
- C is kWh/Therm which is 29.3
- e is the efficiency of your specific furnace (.92 average)
- G is $/Therm (Take your gas bill $/Therm and add factor for monthly rate and taxes = $1.15 for Chicago on average)
- Then plug in the numbers and solve.

Economic Balance Point Calculation – Natural Gas

BeCOP = Breakeven Coefficient of Performance

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

E = $/kWh

C = kWh/therm **(constant)**

Ef = Efficiency of furnace

G = $/therm

1 gal propane = 26.8 kWh
1 therm natural gas = 29.3 kWh

Example House Calculation

$$BeCOP = \frac{(0.10 \times 29.3 \times 0.96)}{0.95}$$

BeCOP = 2.9

E = $0.10/kWh

C = 29.3 kWh/gal natural gas

Ef = 0.96 (96% AFUE)

G = $0.95/therm

Use the Performance Specs chart and BeCOP to estimate the economic balance point

BeCOP = 2.9

- Find the **Rated COP** at different temps
- Depending on where the **BeCOP** falls, estimate the **economic balance point**

Our estimate: ~30°F

Heating/ Cooling	Outdoor Dry Bulb	Unit	Min	Rated	Max
Heating	47°F	Btu/h	11,500	27,400	35,000
		kW	0.91	2.47	3.73
		COP	3.7	**3.25**	2.75
Heating	17°F	Btu/h	6,400	19,400	25,500
		kW	0.82	2.23	3.31
		COP	2.25	**2.55**	2.26
Heating	5°F	Btu/h	5,400	20,800	20,800
		kW	0.83	3.1	3.1
		COP	1.91	**1.97**	1.97
Heating	-3°F	Btu/h	5,400	-	18,800
		kW	0.93	-	2.85
		COP	1.7	-	1.93

What if the customer has propane?

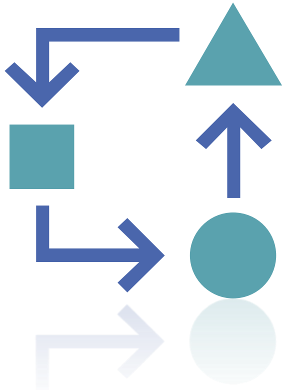
BeCOP = 1.3

- Find the **Rated COP** at different temps
- Depending on where the **BeCOP** falls, estimate the **economic balance point**

Our estimate: ~ 0°F

Heating/ Cooling	Outdoor Dry Bulb	Unit	Min	Rated	Max
Heating	47°F	Btu/h	11,500	27,400	35,000
		kW	0.91	2.47	3.73
		COP	3.7	3.25	2.75
Heating	17°F	Btu/h	6,400	19,400	25,500
		kW	0.82	2.23	3.31
		COP	2.25	2.55	2.26
Heating	5°F	Btu/h	5,400	20,800	20,800
		kW	0.83	1.97	3.1
		COP	1.91	1.97	1.97
Heating	-3°F	Btu/h	5,400	-	18,800
		kW	0.93	-	2.85
		COP	1.7	-	1.93

Summary of key milestones



Understand	Understand the resident's goals, pain points, wants, and budget as a guide
Perform	Perform an accurate load calculation
Design around	Design around application and fuel types
Evaluate	Evaluate ductwork
Size and Select	Size and Select to the right application and fuel type
Use Tools	Use tools that help you sell and instill confidence!

Right Sizing Journey

1. Identify homes loads.
Identify resident wants and needs.

2. Recognize applications and limitations.
Identify fuel types.

3. Evaluate equipment that can meet goals.
Determine how far residents wish to go.

4. Install properly.
Educate residents to operation.
Set controls.

DAY 1

Communicating controls

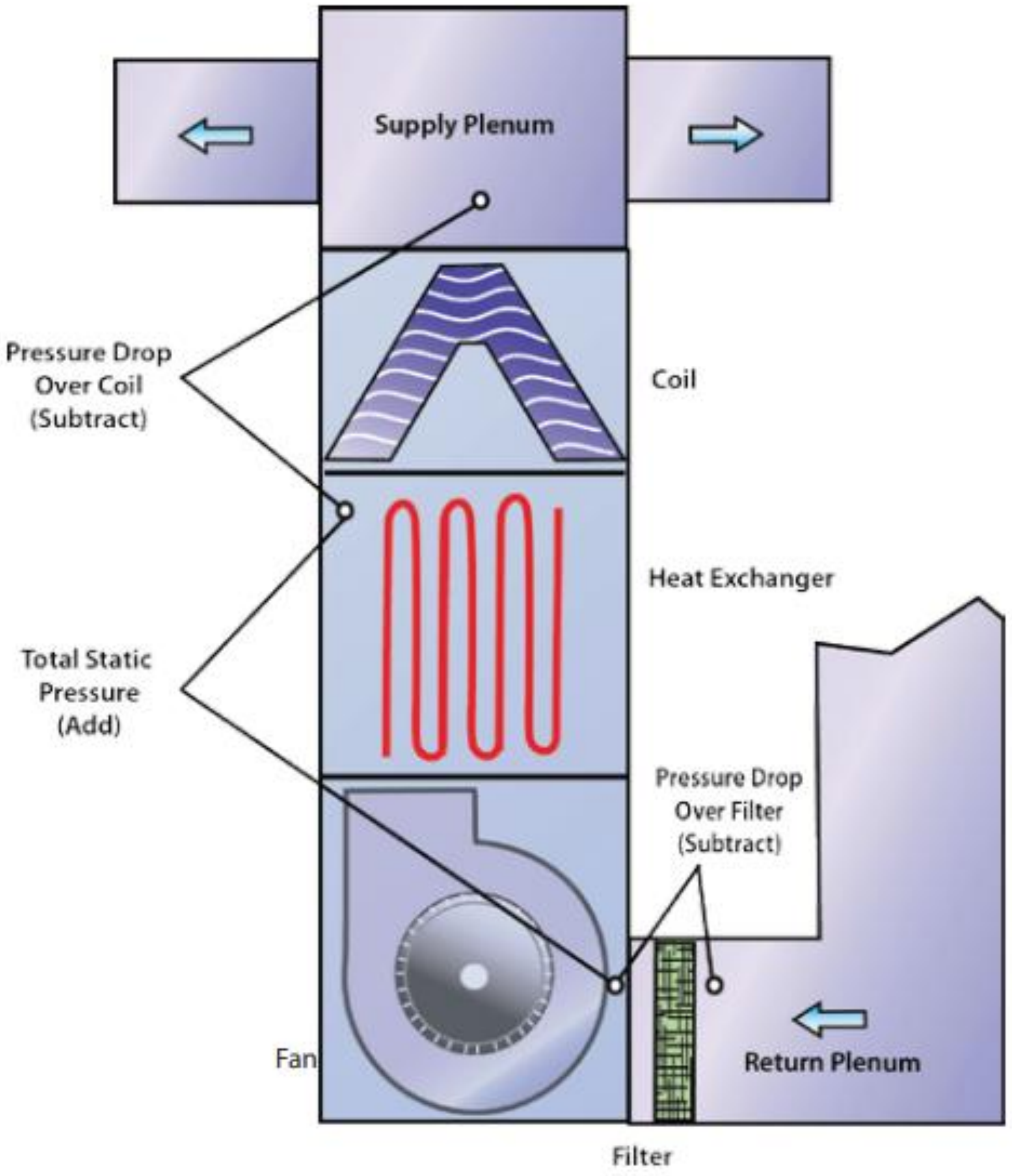
- Proprietary systems that communicate between the thermostat, indoor unit and outdoor unit need a thermostat that can communicate in order to operate in the most efficient way possible.
- Fully modulating systems that can incorporate a staged thermostat can lose stages of operation due to the limited ability of the controls.
- Unitary and ductless products are both affected by staged controls, check with your manufacturer representative before installing a staged thermostat.

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



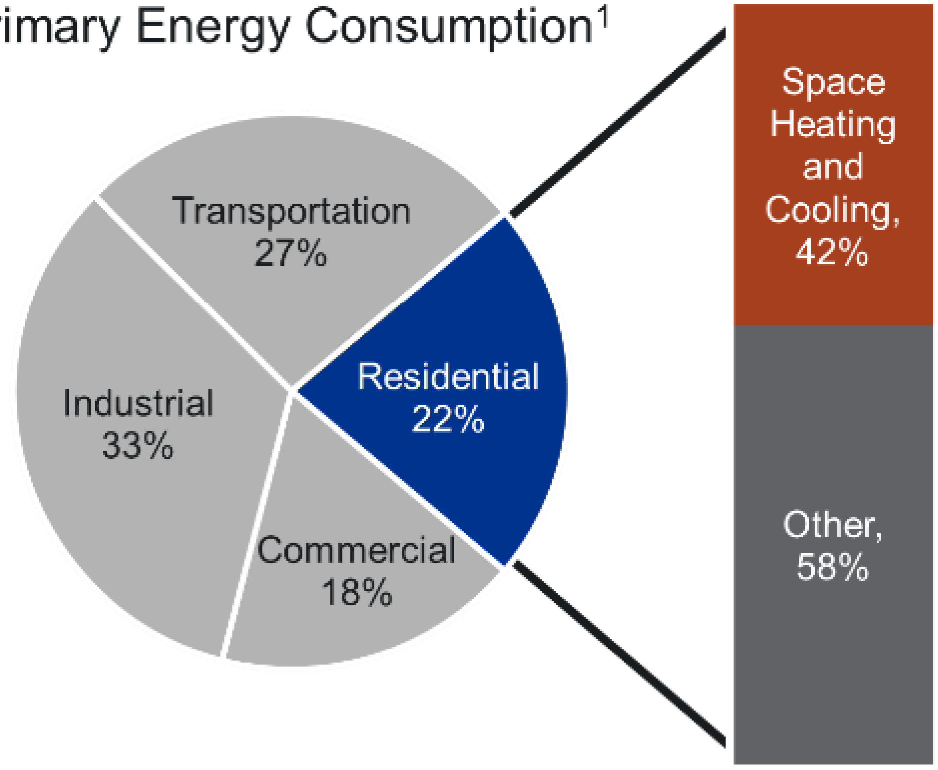
“First Year of Maintenance… Free with new system!”

System commissioning?

Why Residential HVAC Matters

- ✓ Comfort
- ✓ Health and Safety
- ✓ Energy Use
- ✓ Carbon Emissions

Primary Energy Consumption[1]



HVAC Efficiency Over the Years

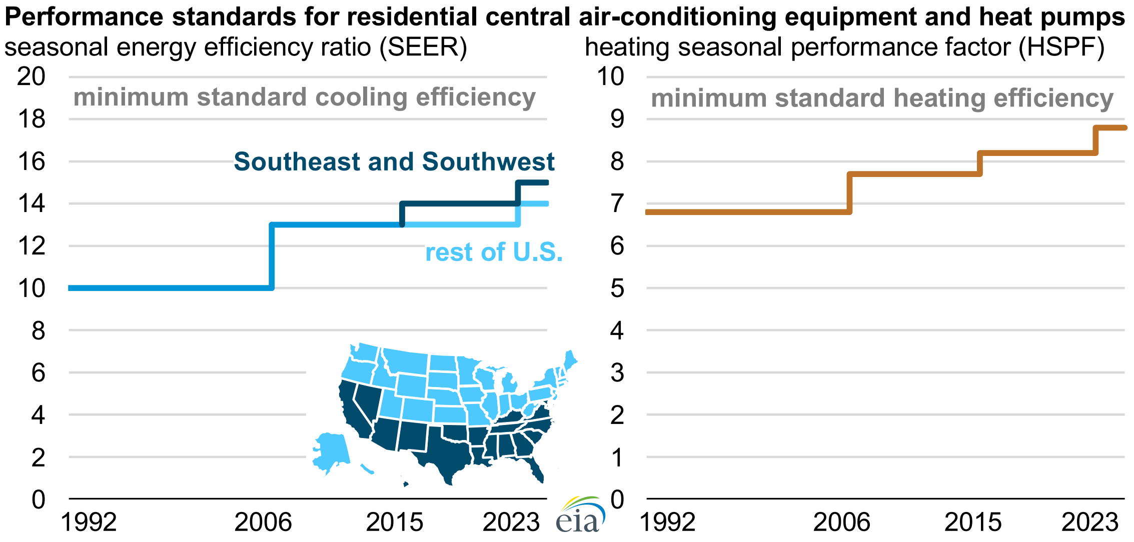


Figure: Performance standards for residential central air-conditioning equipment and heat pumps[1]

- Code-driven minimum HVAC efficiency continues to increase
- Premium high-efficiency HVAC units perform much better than code minimum
- Heat pumps are on the rise
- Efficiencies are not always realized in the field

Impact of Improper Installation

Improper installation or maintenance of central air conditioning (CAC) and air-source eat pump (ASHP) systems results in decreased performance, energy waste, and reliability concerns.

- At least **one energy wasting fault in 70-90% of homes**[2]
- At least 20% of CAC/ASHPs experience failure due to improper installation[2]
- Estimated **9% energy waste** due to decreased CAC/ASHP performance due to inadequate airflow and improper refrigerant charge[3]

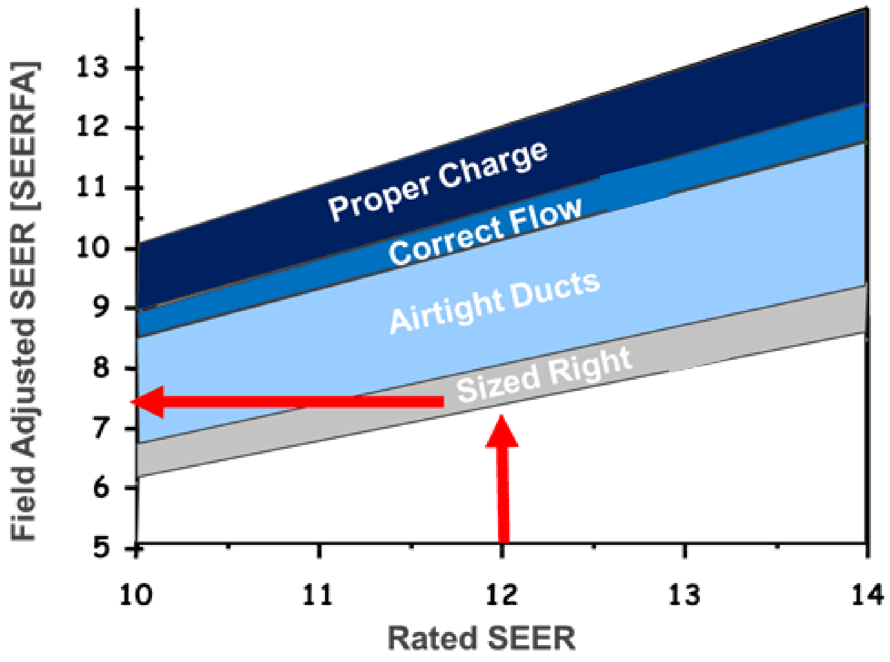
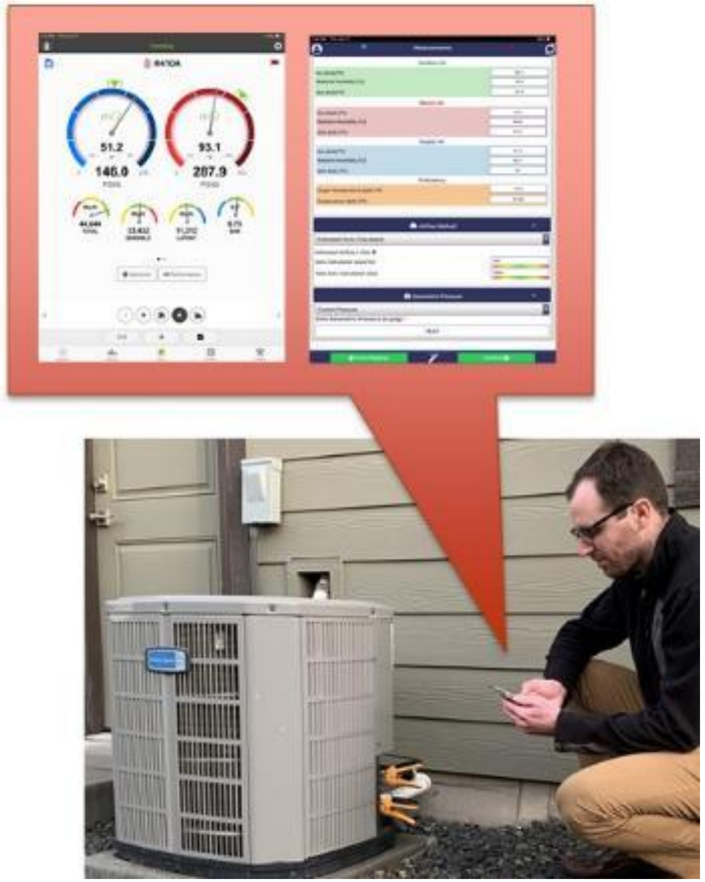


Figure: Theoretical field adjusted SEER caused by installation and sizing issues[1]

What Quality Contractors Strive For

- ✓ Eliminating callbacks
- ✓ Ensuring every HVAC system runs at peak efficiency
- ✓ Every HVAC system is commissioned

Why Smart Diagnostic Tools?



- Expand Capabilities
- Streamline Processes
- Ensure HVAC Efficiency
- Improve Customer Satisfaction
- Boost Reputation
- Create Business Value

Old School Tools

R-410A Pressure-temperature chart

PSIG	°F	PSIG	°F	PSIG	°F	PSIG	°F	
12	−37.7	114	37.8	216	74.3	318	100.2	
14	−34.7	116	38.7	218	74.9	320	100.7	
16	−32.0	118	39.5	220	75.5	322	101.1	
18	−29.4	120	40.5	222	76.1	324	101.6	
20	−36.9	122	41.3	224	76.7	326	102	428
22	−24.5	124	42.2	226	77.2	328	102.4	430
24	−22.2	126	43	228	77.8	330	102.9	432
26	−20.0	128	43.8	230	78.4	332	103.3	434
28	−17.9	130	44.7	232	78.9	334	103.7	436
30	−15.8	132	45.5	234	79.5	336	104.2	438
32	−13.8	134	46.3	236	80	338	104.6	440
34	−11.9	136	47.1	238	80.6	340	105.1	442
36	−10.1	138	47.9	240	81.1	342	105.4	444
38	−8.3	140	48.7	242	81.6	344	105.8	446
40	−6.5	142	49.5	244	82.2	346	106.3	448
42	−4.5	144	50.3	246	82.7	348	106.6	450
44	−3.2	146	51.1	248	83.3	350	107.1	452
46	−1.6	148	51.8	250	83.8	352	107.5	454
48	0	150	52.5	252	84.3	354	107.9	456
50	1.5	152	53.3	254	84.8	356	108.3	458
52	3	154	54	256	85.4	358	108.8	460

Find data plate image:
Target Subcooling = 10°F

Measurement Uncertainty

Take for example a 500-psi gauge:

- Class B, 3%-2%-3%
  - ±10 psi to ± 15 psi
- Class 1, 1% Accuracy
  - ±5 psi

Analog

Read between the lines!

For 580-psig max digital probes/gauges:

- Fieldpiece JL3PR Pressure Probe
  - ±1 psi to ±2 psi
- Fieldpiece SM380V
  - ±1 psi to ±2.74 psi

Digital

Measurement Uncertainty


ACCA Standard 5

HVAC Quality Installation Specification

Minimum Design and Installation Requirements for Residential and Commercial Heating, Ventilating, and Air Conditioning (HVAC) Applications

Example:

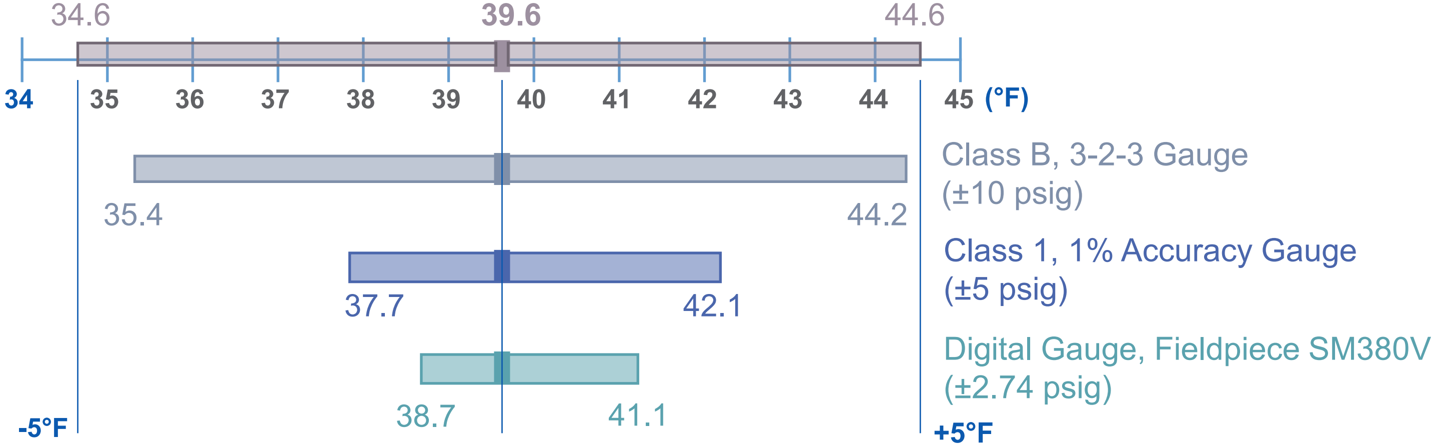
R410A, non-TXV,
Indoor Wetbulb = 66°F, Outdoor Drybulb = 95°F
Target Superheat of 10.0°F

Measured Suction Temp = 49.6°F
Suction Pressure = 118.0 psig → 39.6°F Saturation Temp

4.3.1 Requirements:

The contractor shall ensure:

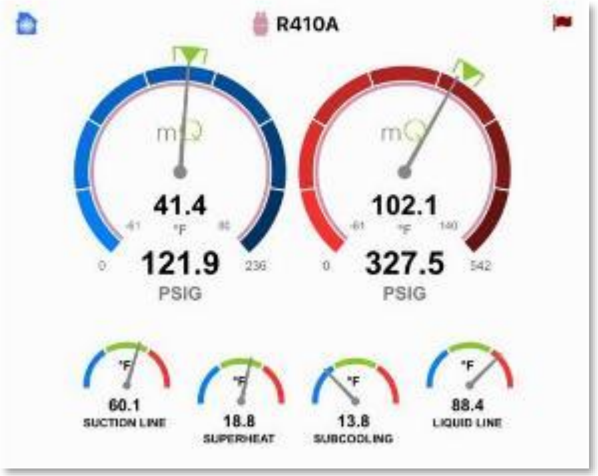
a) For the SUPERHEAT method, system refrigerant charging per OEM data/instructions and within ±5°F of the OEM-specified superheat value



Smart Diagnostic Tools

Digital Sensors, Probes, and Manifolds

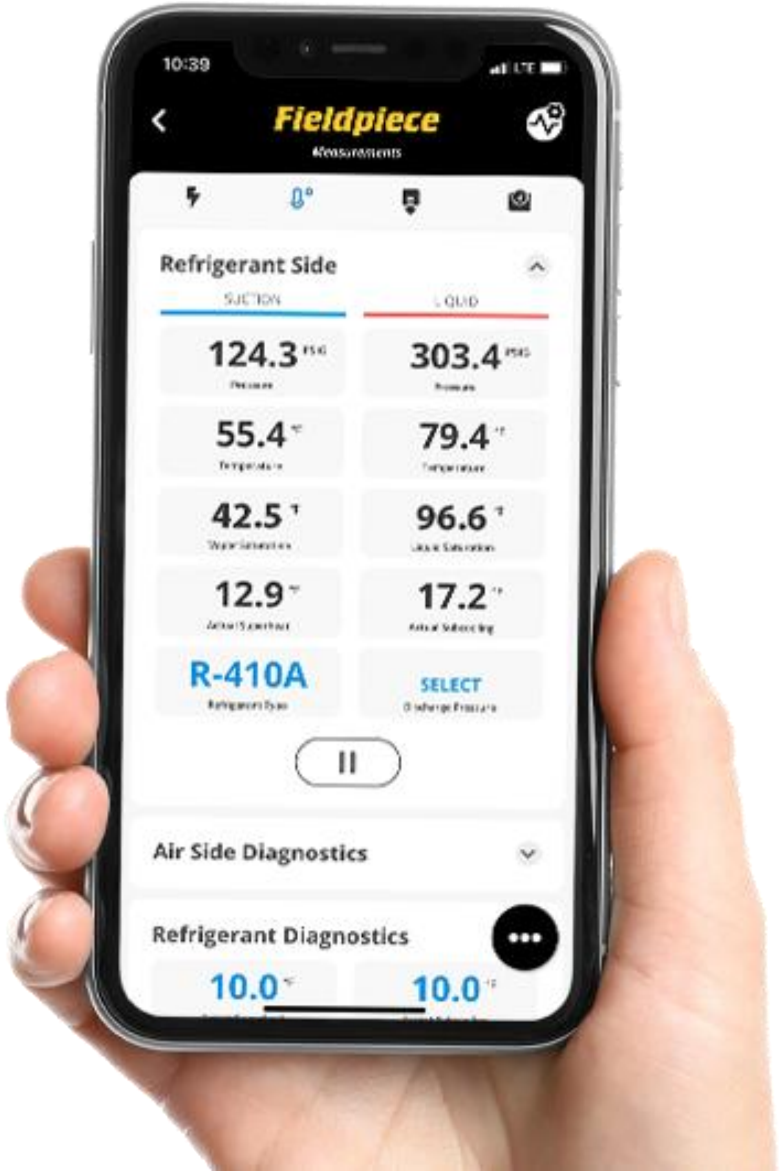
Smartphone/Tablet Diagnostic App

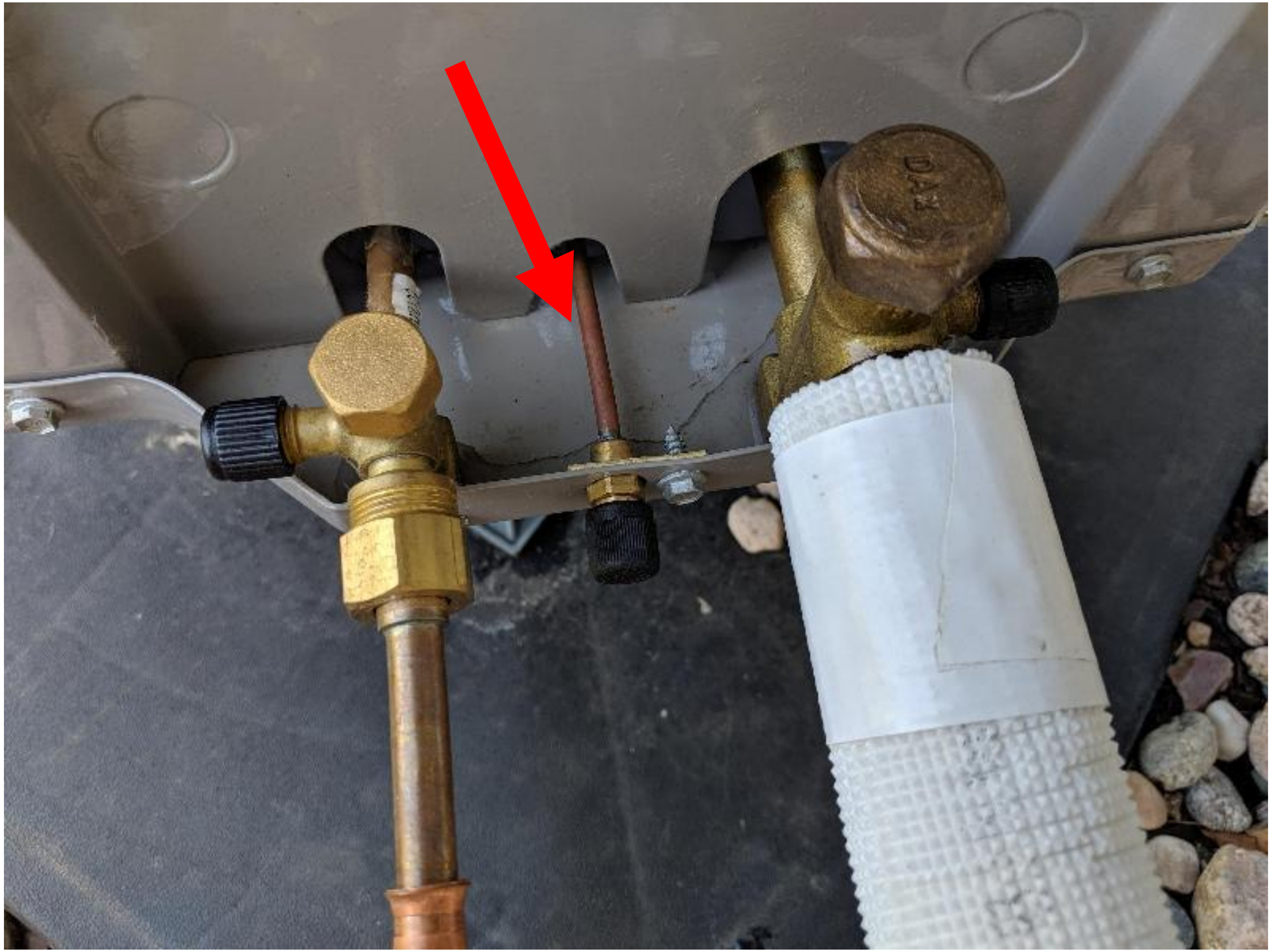


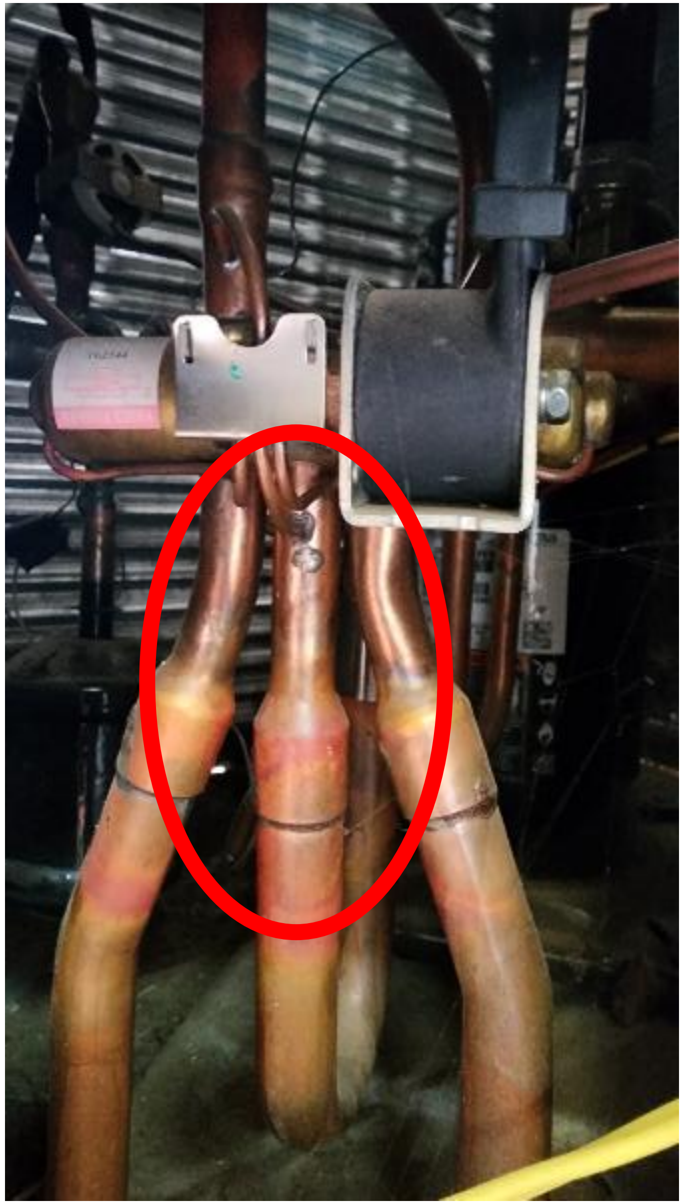
- ✓ Wirelessly connected
- ✓ Provides Diagnostics
- ✓ Suggest Corrective Actions
- ✓ Run Performance Calculations

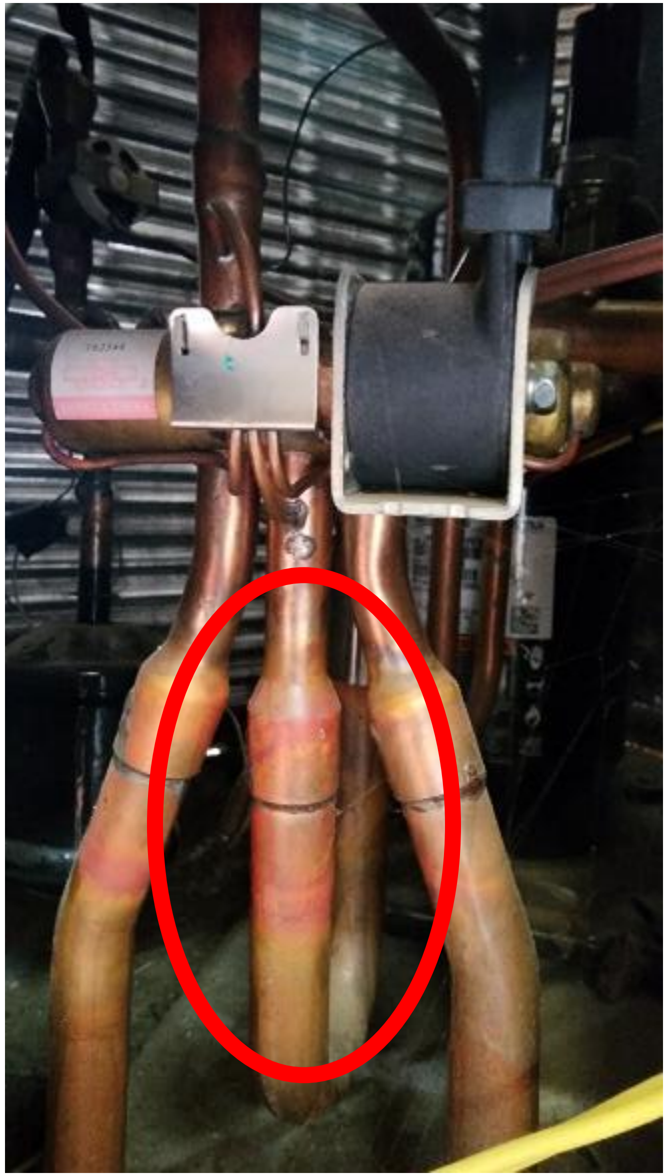
- Digital Manifolds
- Pipe Clamps
- Pressure Probes
- Clamp Meters
- Psychrometer
- Manometer
- Refrigerant Scale
- Vacuum Gauge

…all in one informative application

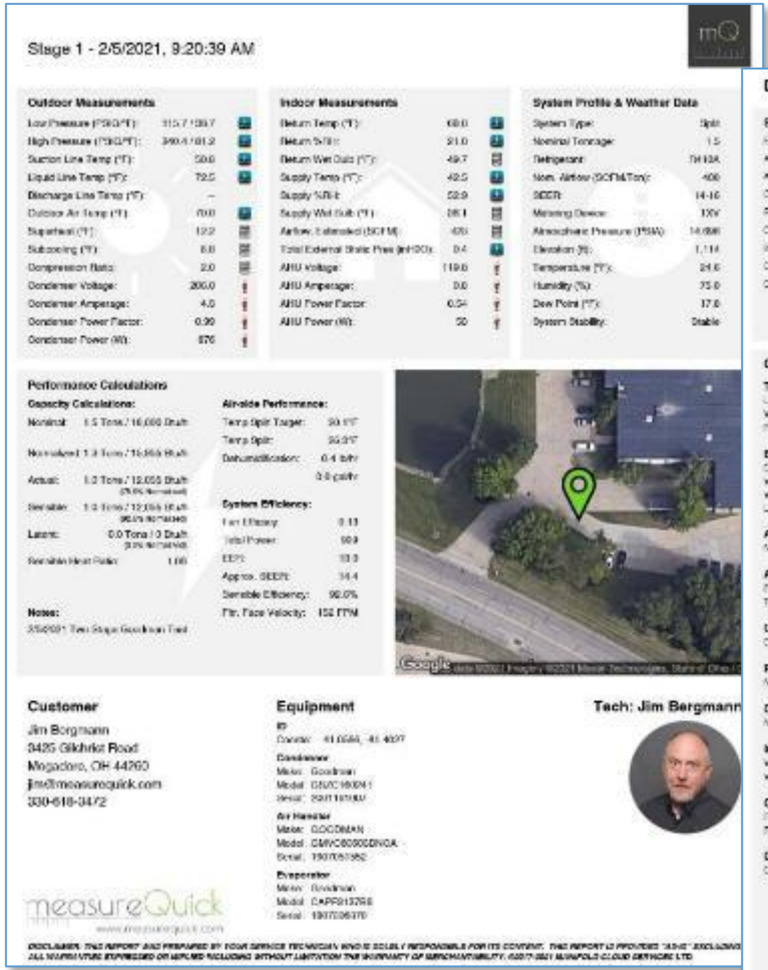


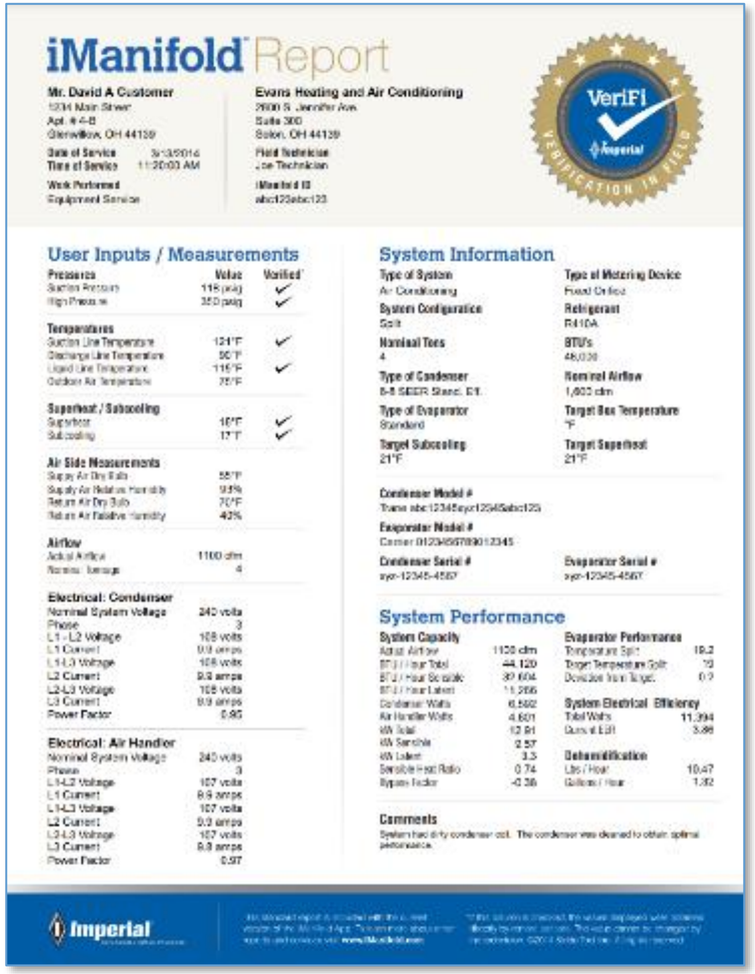






Commissioning





A/C System Vitals Report

Jimmy Emrick

Jim Bergmann

Date of Service: 4/12/2022
Time of Service: 11:09:04 AM

What Are Your System Vitals?
Just like your health vitals, temperature, pulse, blood pressure etc, your A/C system vitals show the overall health of your air conditioning system. These vitals account for both the refrigerant and air delivery side of the system. System targets that are out of range are typically related to a system diagnostic listed below. Correcting the diagnostic faults, if possible, should put the system vitals back in the normal range.

YOUR SYSTEM SCORE

100% A+

Refrigerant Charge

In Range | Out of Range

Superheat: 11.7 °F

Low	Normal (8.3 - 18.3)	High

Subcooling: 10.4 °F

Low	Normal (3.0 - 42.0)	High

Heat Transfer

Condenser Approach: 3.3 °F

Low	Normal (1.5 - 13.0)	High

Temperature Split: 19.0 °F

Low	Normal (15.7 - 21.7)	High

Air Distribution & Filtration

Total External Static Pressure: 0.57 inH2O

Low	Normal (< 0.8)	High

Filter Face Velocity: 212.6 FPM

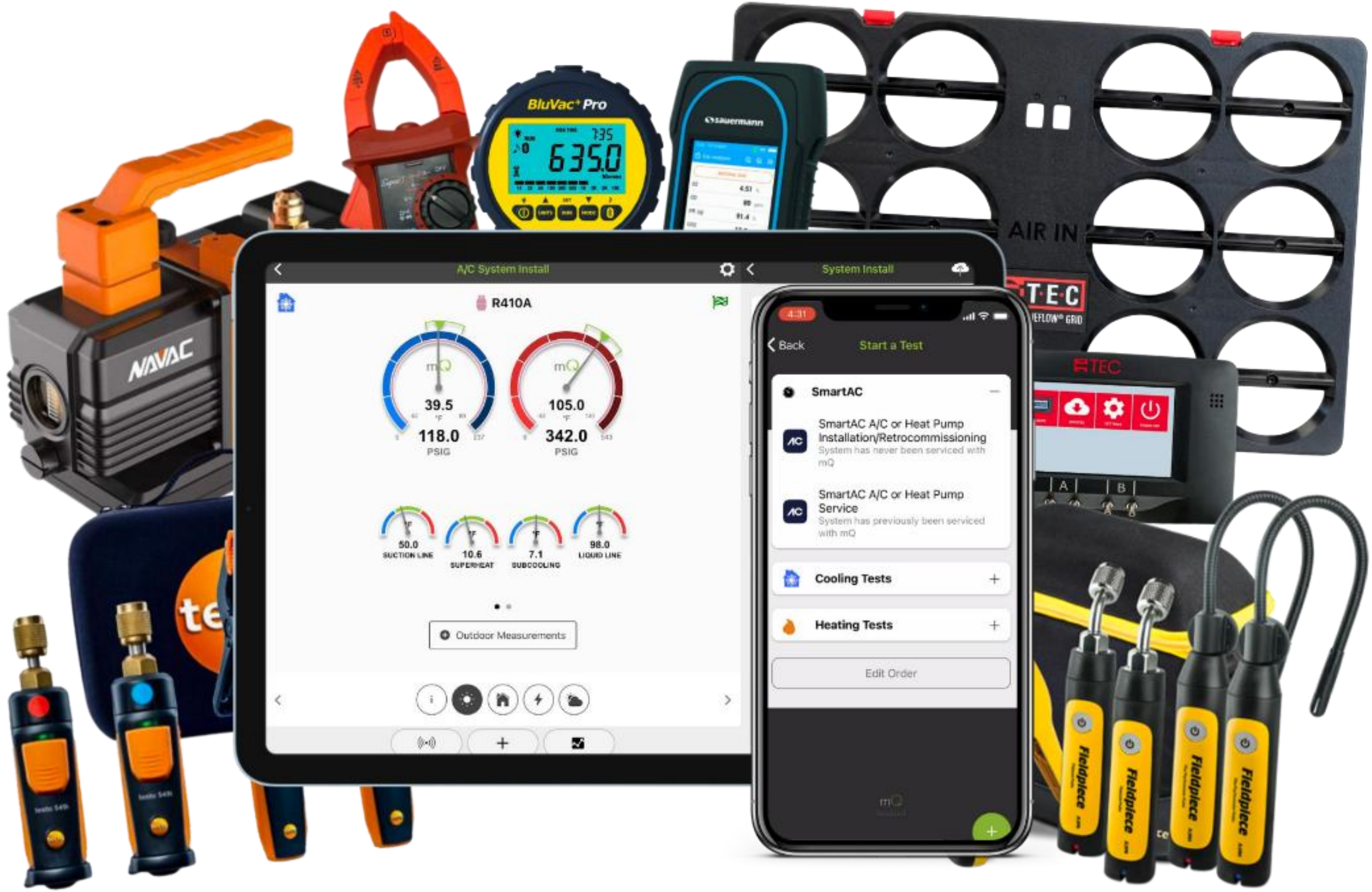
Low	Normal (< 500.0)	High

Subsystem Review

Not yet reviewed

System Diagnostics

No system-wide issues were detected.



BluVac+ Pro
635.0
sauermann
NAVAC
AIR IN
T·E·C
TEC
A
B
A/C System Install
R410A
39.5
118.0
PSIG
105.0
342.0
PSIG
50.0
SUCTION LINE
10.6
SUPERHEAT
7.1
SUBCOOLING
98.0
LIQUID LINE
Outdoor Measurements
System Install
Back
Start a Test
SmartAC
SmartAC A/C or Heat Pump Installation/Retrocommissioning
System has never been serviced with mQ
SmartAC A/C or Heat Pump Service
System has previously been serviced with mQ
Cooling Tests
Heating Tests
Edit Order
Fieldpiece
Fieldpiece
Fieldpiece
Fieldpiece

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.

Education through Communication.

"Arrive a stranger, Leave as a friend"

Incentive Programs

Home Energy Rebates

Pennsylvania Department of Environmental Protection

Agenda

- HEAR // 50122
- HER // 50121
- TREC
- Questions

Home Electrification & Appliance Rebates

Pennsylvania Department of Environmental Protection

HEAR: A High-Level Overview

- Home Electrification and Appliance Rebates (HEAR) was created by the Inflation Reduction Act of 2022
  - 8.8 Billion USD allocated for all the Home Energy Rebate Programs
- Penn Energy Savers Program
  - Encourages adoption of appliances that are electric, consume less energy, and lower costs
  - PA allocated $129,000,000

Pennsylvania
Department of
Environmental Protection

HEAR: Income Eligibility

- All qualified applicants must make below 150% of their county's AMI
- 100% of project costs can be rebated if applicants are below 80% of AMI
- Eligibility Documents: IRS 1040 Form, Employer W-2 for each member of household, proof of residence
    - Other income verification sources will be considered during each application
- Categorical eligibility from participation in other programs is valid income verification
- It is the resident(s) living in the dwelling that is income qualified

Pennsylvania Department of Environmental Protection

HEAR: Rebate Values

Upgrade Type	Qualified Product	Rebate Amount Not to Exceed
Appliance	Heat Pump Water Heater	$1,750
	Heat Pump for Space Heating or Cooling	$8,000
	Electric Stove, Cooktop, Range, Oven	$840
	Heat Pump Clothes Dryer	$840
Building Material	Electric Load Service Center	$4,000
	Insulation, Air Sealing, and Ventilation	$1,600
	Electric Wiring	$2,500
Maximum Rebate		$14,000

Eligible Rebate Recipient	Income Level	Rebate Amount Not to Exceed
Low- or Moderate-Income (LMI) Household or Eligible entity representative representing LMI household	Less than 80% AMI	100% of qualified project cost
	81%-150% AMI	50% of qualified project cost
Owner of multifamily building or Eligible entity representative representing owner of multifamily building	At Least 50% of residents with income less than 80% AMI	100% of qualified project cost
	At least 50% of residents with income of 81%-150% AMI	50% of qualified project cost

Home Efficiency Rebates (HER)

Pennsylvania Department of Environmental Protection

HER: A High-Level Overview

- Home Efficiency Rebates (HER) is one of the Home Energy Rebate programs created by the Inflation Reduction Act of 2022
  - 8.8 Billion USD allocated for all the Home Energy Rebate Programs
  - PA allocated $129,000,000
- Encourages adoption of energy efficiency measures in low-income multi-family buildings – must be 20% energy reduction
  - Higher rebates for projects achieving 35% energy reduction

Pennsylvania Department of Environmental Protection

HER: PA's Design Considerations

- Limited programmatic funding for multi-family projects
- Limited programmatic low-income funding
- Homes with electric resistance have higher energy burden than homes with gas
- 7% of multifamily homes heat with delivered fuels
- Costs for major energy efficiency upgrades can range from $15,000 to $20,000
- Heat Pump Installation = ~31% energy savings at a cost of $9,520
- Heat Pump & Weatherization = ~54% energy savings at a cost of $16,020

Pennsylvania Department of Environmental Protection

HER Rebate Values

Modeled Energy Savings	Income Level	Details
20-34%	<80% AMI	Lesser of $10k or 100% of project cost
	81-150% AMI	Lesser of $2k or 50% of project cost
+35%	<80% AMI	Lesser of $16k or 100% of project cost
	81-150% AMI	Lesser of $4k or 50% of project cost

Training for Residential Energy Contractors (TREC)

TREC: Heat Pumps in PA

Pennsylvania Department of Environmental Protection

It's important to get heat pumps installed correctly

- Supplements existing training programs
  - New Worker Track
    - Wraparound Services
    - Stipends for training
  - Existing Worker Track
    - NATE certification
    - Stipends for training
- Training Syllabus Review & Evaluation

Pennsylvania Department of Environmental Protection

Get In Touch!

Home Energy Rebates Team

Energy Programs Office

PA DEP

400 Market St.

Harrisburg, PA 17101

...

RA-EPHomeEngRebates@pa.gov

The Department of Environmental Protection's mission is to protect Pennsylvania's air, land and water resources and to provide for the health and safety of its residents and visitors, consistent with the rights and duties established under the Environmental Rights Amendment (Article 1, Section 27 of the Pennsylvania Constitution).

FirstEnergy PA Energy Efficiency Program

Phase IV: June 1, 2021 – May 31, 2026

Connect to Our Team!

FirstEnergy

- Ryan Novosedliak, Program Implementation Manager
  - rnovosedliak@firstenergycorp.com

FRANKLIN ENERGY

- Patricia Forero, Program Manager
  - pforero@franklinenergy.com

WILLDAN

- Payam Esmaili, Program Manager
  - Pesmaili@willdan.com

CLEAResult

- James Fago, Program Manager
  - james.fago@clearesult.com

Connect on LinkedIn!

Business Energy Solutions – Pennsylvania

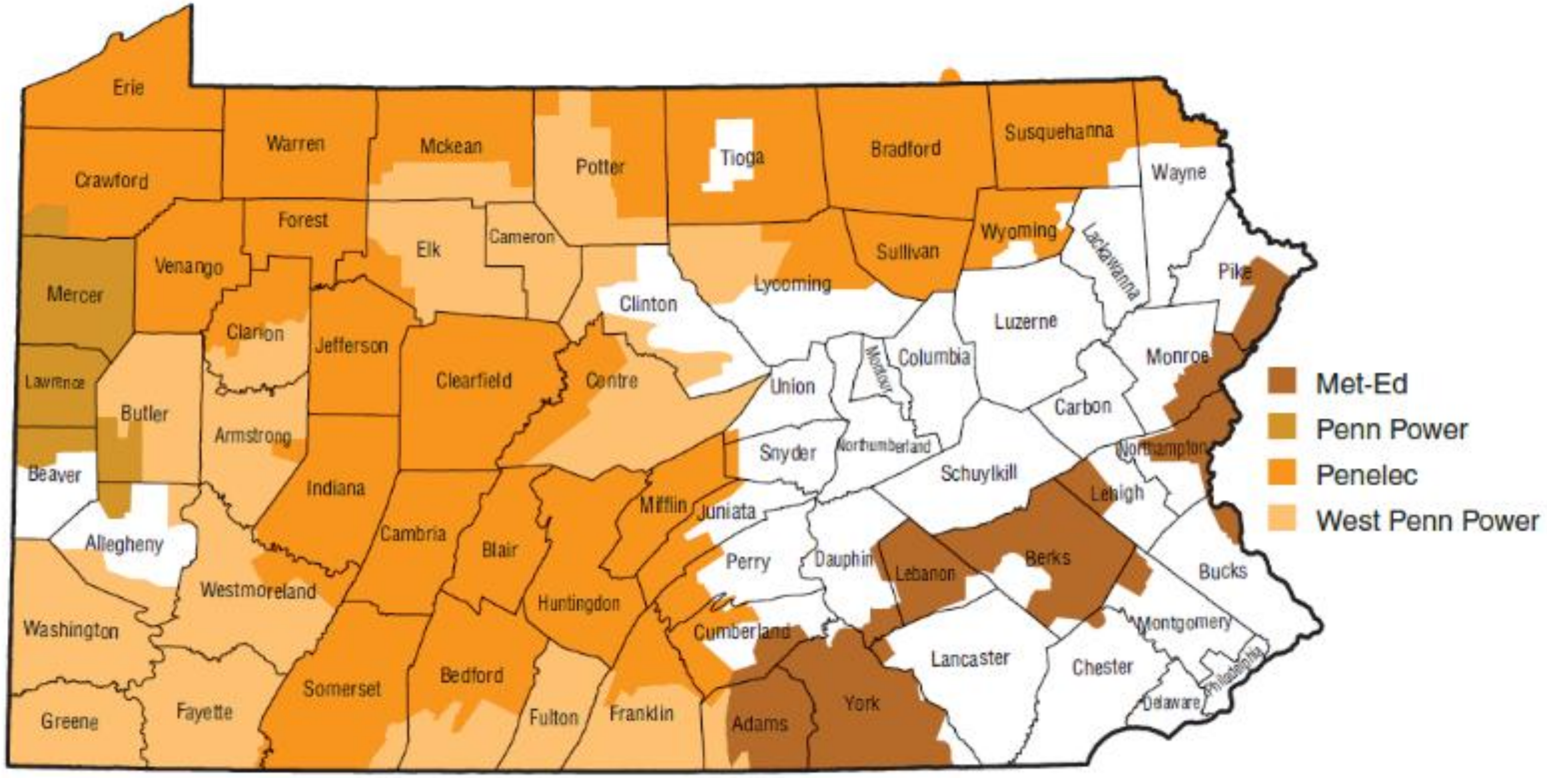
FOLLOW US ON LinkedIn

FirstEnergy

FirstEnergy Pennsylvania Utilities

FirstEnergy PA is comprised of four Operating Companies:

- Met-Ed, Penelec, Penn Power, West Penn Power



FirstEnergy PA Act 129: The Basics

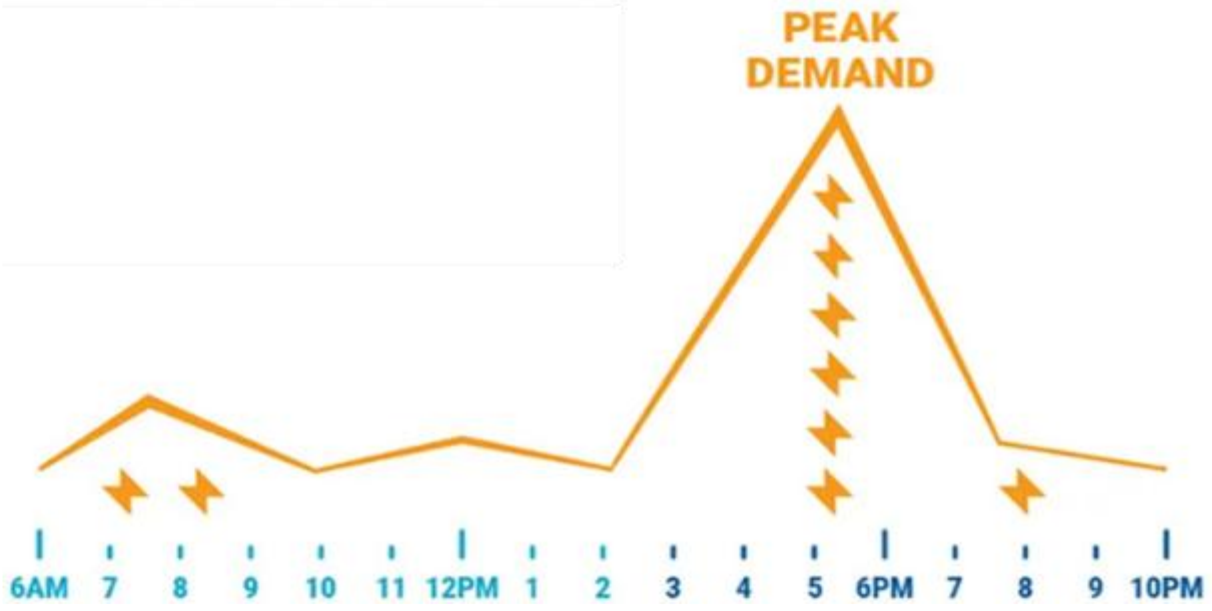
- ACT 129 is a law signed in 2008
- Requires all PA Electric Distribution Companies to offer rebates for reducing kWh and Peak Demand
  - Regulated by the Pennsylvania Utility Commission (PUC)
- Paid for by PA Rate Payers from their utility bills
- Operates in Phases
  - Currently in Phase IV, running through May 31, 2026
  - Phase V anticipated to begin June 1, 2026

FirstEnergy Act 129 Phase IV Peak Demand

New to Phase IV is ***Peak Demand***

This is demand (kW) reduction at:

- June 1- August 31
- Monday – Friday (Excluding Holidays)
- 2:00 – 6:00 PM



Why this time period?

- This is when the grid faces highest demand
  - Summer Afternoon

FirstEnergy Act 129 Phase IV: Eligibility

Open to ALL FirstEnergy PA Customers with an Eligible Rate Code

- Residential

- Small Commercial and Industrial (SCI)
  - Defined by Demand (< 400kW) and Rate Schedule

- Large Commercial and Industrial (LCI)
  - Defined by Demand (> 400kW) and Rate Schedule

- Government / Non-Profit/Institutional (GNI)

FirstEnergy Act 129 Phase IV: Incentives

Check Online for the latest incentive rates by Program, Operating Company and Sector!

www.energysavepa.com

A signed Offer Letter is required to reserve funds

Performance Rebates

Paid on a cents per unit ($/kWh)

Examples include:

- Lighting
- Custom
- Solar
- Custom Building Improvement

Prescriptive Rebates

Paid on a dollars per measure ($/tons)

Examples include:

- HVAC
- Food Service
- LED Exit Signs
- Appliances

FirstEnergy

FirstEnergy PA Phase IV Breakdown

FRANKLIN ENERGY

- Lighting / Prescriptive
- Custom
- Solar

WILLDAN

- Building Tune-Up (BTU)
- Building Operators Certifications (BOC)
- Custom New Construction (CNC)
- Custom Building Improvement (CBI)

CLEAResult®

- Relationship Management
- Application Assistance
- Savings Calculations

Check out the Website!

www.energysavepa.com and scroll to Energy Savings for Business

FirstEnergy PA Phase IV: HVAC

- Rebate is Prescriptive

- Eligible Measures include:
  - Air Conditioners
  - Water-Cooled Electric Chillers
  - Heat Pumps
  - PTAC/PTHP

FirstEnergy PA Phase IV: Custom

Incentive:

- Performance Based
- Capped at 50% of Project cost, up to $500,000

Eligible Measures:

- Process Upgrades
- Air Compressors Upgrades
- Air-Cooled Chillers
- Motor Upgrades
- System Improvements
- Data Center Retrofits/Upgrades
- Chilled Water System Redesign
- VFD Applications
- Custom Controls
- Agricultural Process Improvement
- Contact Program for other possible Energy Conservation Measures (ECM's)

Ineligible Measures:

- Power Factor Correction
- Motor Soft Starts
- Fuel Switching
- Used Equipment

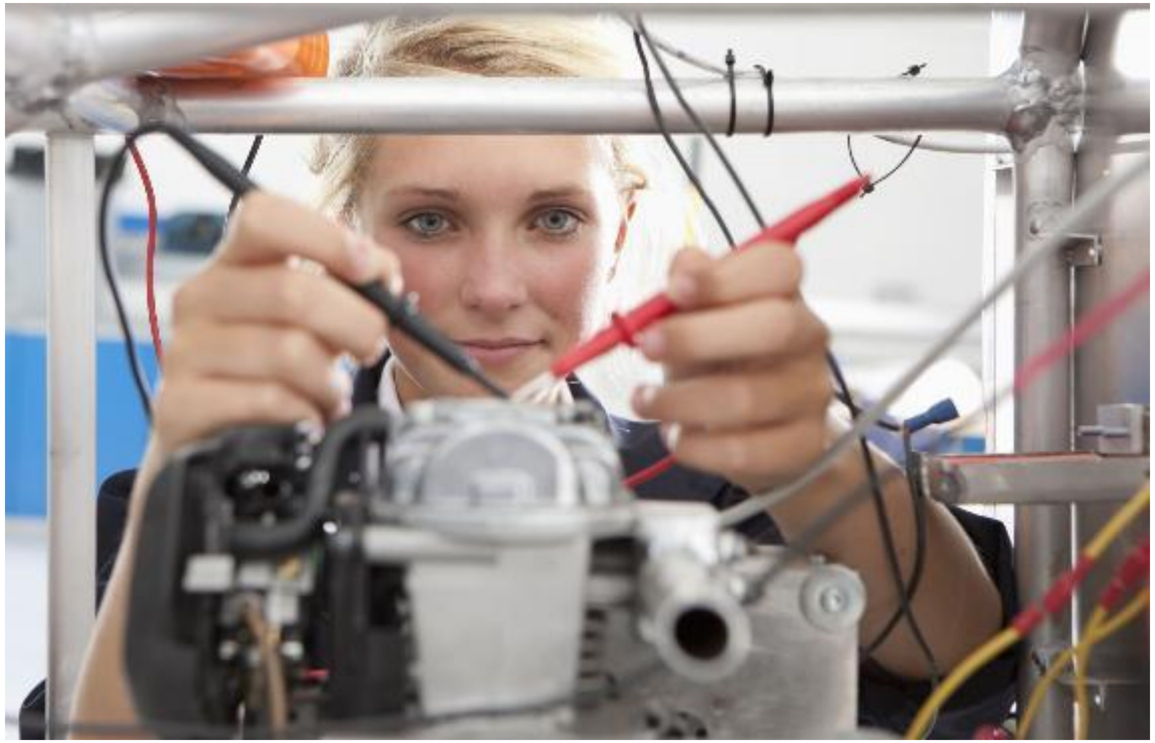
FirstEnergy®

FirstEnergy PA Phase IV: Facility Audit

- Rebate is Performance

- Eligible Measures include:
  - Industrial process or system audit
  - ASHRAE Level II

- Two Part Incentive
  - Audit Cost
    - Eligible participants will receive an incentive based on annual kWh saved, not to exceed 50 percent of the audit cost or $10,000, whichever is less, upon completion of the ***installation of qualifying audit recommended measures at the customers' facility.***
  - Measure Incentive
    - Incentives are paid for the installation of qualifying audit-recommended measures.



FirstEnergy

FirstEnergy PA Phase IV: Building Tune Up

- Rebate is Project Based
- Eligibility Includes
  - Comprehensive Upgrade include multiple measures.
  - Pre-Approval Required

End Use Category	Measure	
HVAC	▪ Air Source Air Conditioners ▪ Air Source Heat Pumps ▪ Packaged Terminal Air Conditioner ▪ Packaged Terminal Heat Pump ▪ Water Cooled Air Conditioners ▪ Ductless Mini-Split Heat ▪ Pump (DMSHP)	▪ Economizer ▪ Variable Frequency Drive (VFD) Improvements ▪ VSD on Kitchen Exhaust Fan ▪ Heat Pump Hot Water Heaters ▪ Guest Room Occupancy Sensor ▪ HVAC Tune-up
Lighting	▪ Lighting Improvements ▪ Lighting Controls	▪ LED Exit Signs ▪ LED Refrigeration Display Case Lighting
Refrigeration	▪ Variable Speed Refrigeration Compressor ▪ Controls: Evaporator Fan Controller ▪ Anti-Condensation Door Heater Controls ▪ EC Motors Retrofits	▪ Evaporator Coil Defrost Controls ▪ Insulate Bare Suction Pipes – Cooler ▪ Controls: Beverage Machine Controls ▪ Controls: Snack Machine Controls
HVAC	▪ Optimizing HVAC equipment scheduling, setpoints, and system control sequences ▪ Restoring economizer operation ▪ Repairing sensors and other critical system components ▪ Minimizing/eliminating simultaneous heating & cooling ▪ Reducing minimum airflow setpoints	

FirstEnergy

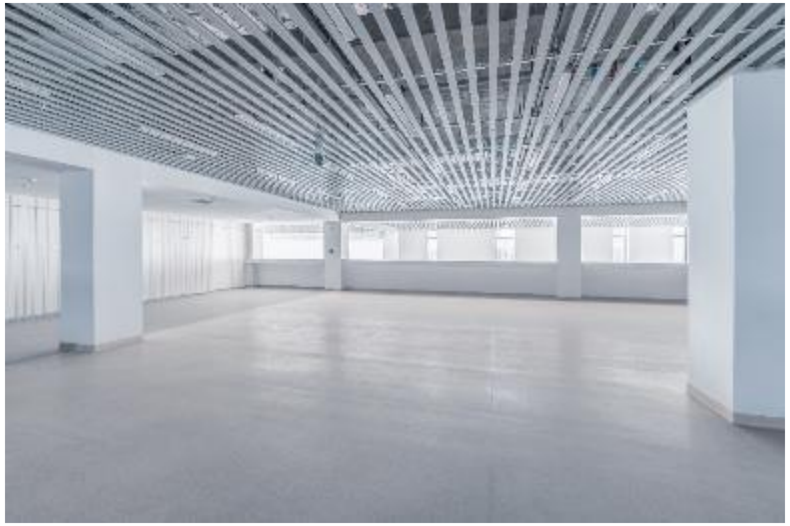
FirstEnergy PA Phase IV: Custom Building Improvements (CBI)

Incentive:

- Performance Based
- Capped at 50% of project cost, up to $500,000

Eligibility

- Must be Multi-Measure Impacting Multiple Systems
  - Building Shell
  - HVAC
  - Lighting
  - Other



Recommend enrolling into the CBI Program before equipment is purchased.

See Website for details!

https://energysavepa-bia.com/

FirstEnergy

FirstEnergy PA Limited Time Offer!

- Building Operations Certification (BOC) Training

- From July 1st, 2025, to December 31st, 2025, FirstEnergy will cover the cost of the course!!

- Go to: https://energysavepa-rcx.com/boc-training

- Training is Virtual or in a Classroom from Clean Energy Center at Penn College
- Courses:
  - BOC I
    - Teaches building operators to find practical, low-cost and no-cost efficiency solutions by working with existing systems. BOC Level I provides an overview of the building envelope and reviews the design, operation and maintenance of energy-using systems and equipment.
  - BOC II
    - Prepares building operators to evaluate the operational performance of their buildings with a focus on improving energy efficiency. Through project assignments, operators learn how to collect and analyze building data in order to prepare a building walk-through plan to identify opportunities to improve performance.

FirstEnergy®

FirstEnergy PA Phase IV: Application Assistance

CLEAResult is vendor neutral resource to help with applications!

For Customers:

- Can help navigate the best option for you!
- Can help to find possible projects in your facility!

For Program Allies:

- Can help find the best possible incentive!
- Can help with the application process!

FirstEnergy

FirstEnergy PA Phase IV Transition

- Phase IV ends on May 31, 2026
- Current Incentive level can be found online!
- Program has funding, but Operating Companies and Sectors can become constrained.
- FirstEnergy anticipates Phase V to begin on June 1, 2026
- If your application should slip beyond Phase IV, FirstEnergy will hold your application for Phase V

FirstEnergy

Focused on Our Future

Questions?

Audience Discussion

Thank you for attending today's event!

FirstEnergy®

ASHP Contractor Training Summit, Pittsburgh, PA Post-Event Survey

FirstEnergy