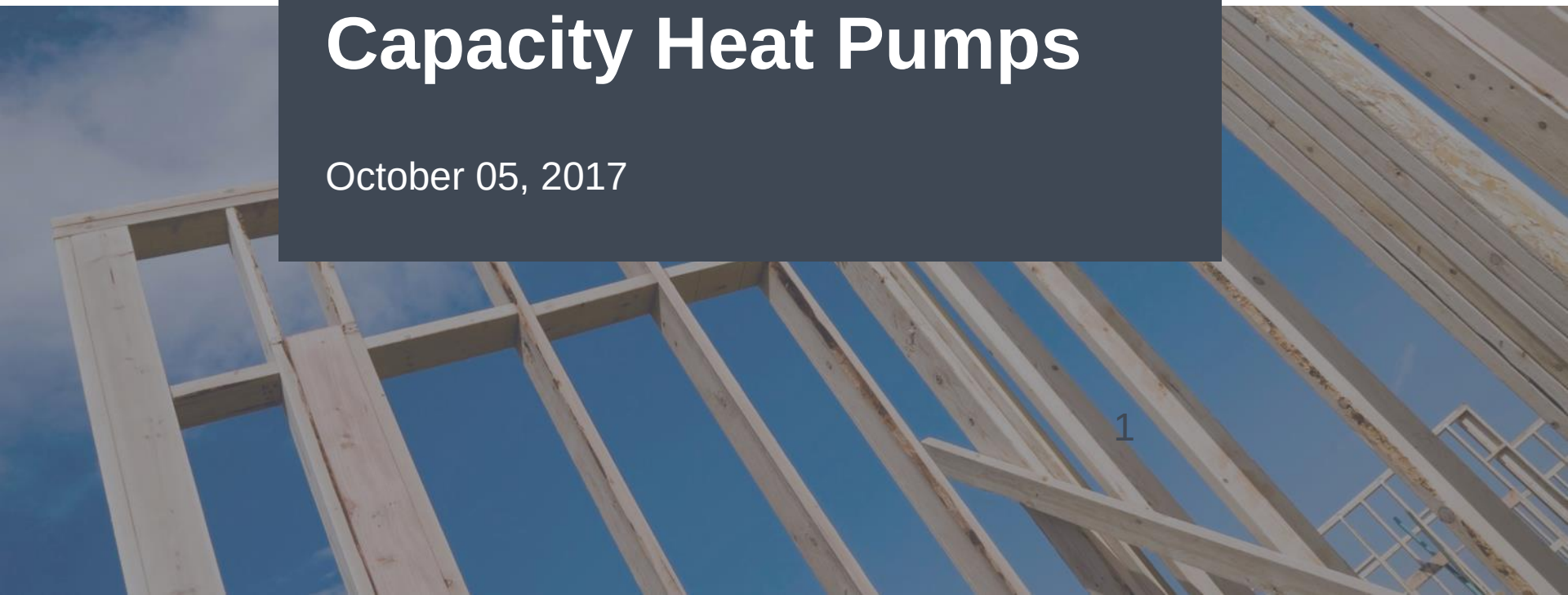
BetterBuiltNW

Working With DHPS and Other Variable Capacity Heat Pumps

October 05, 2017



Housekeeping

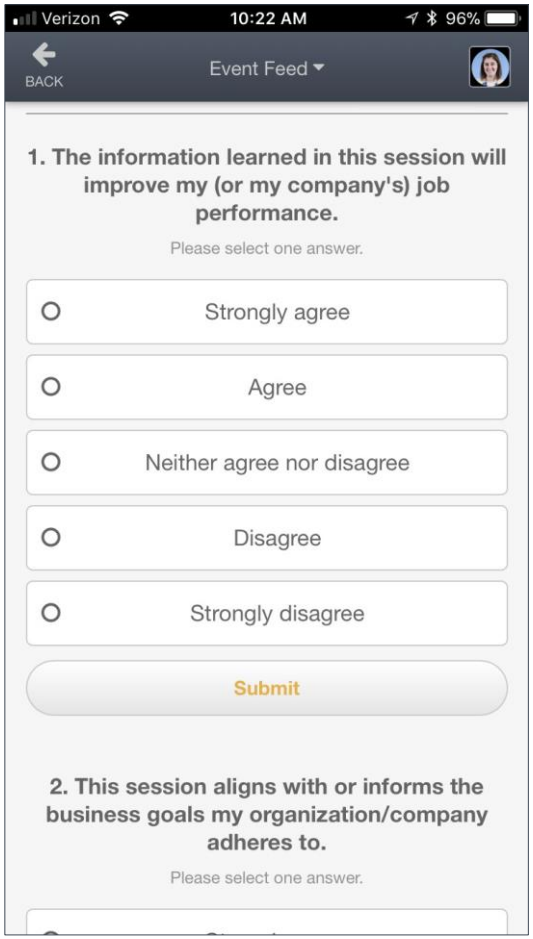
Welcome

- Safety
- Bathrooms
- Cell phones

Session Survey Instructions

At the end of each session, you will be given 5 minutes to complete the session survey.

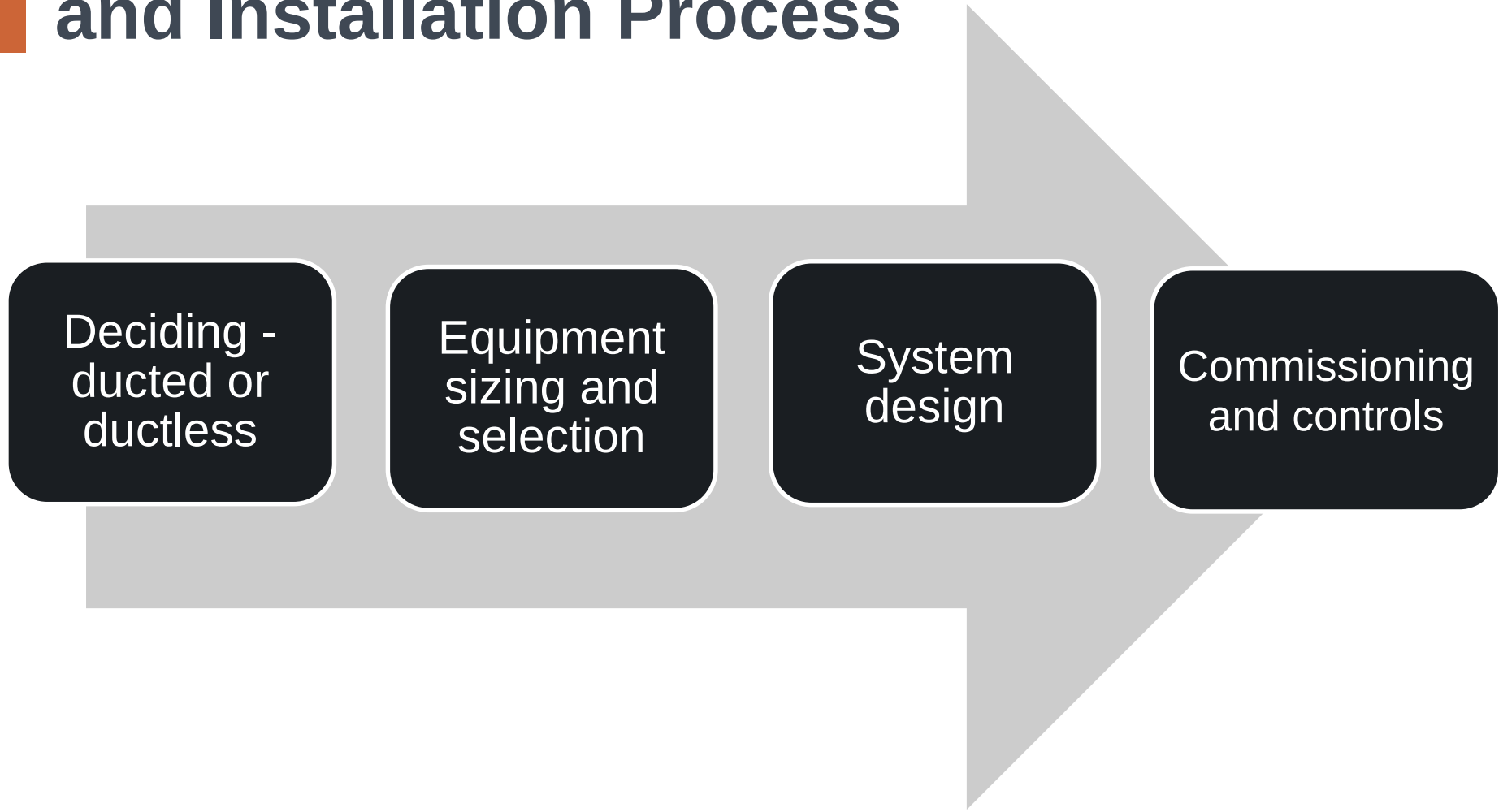
1. Open the “HEF2017” app
2. Navigate to “Agenda” and select the session
3. Scroll down to “Session Feedback”
4. For each question, select answer and hit “Submit”
5. Show completed survey to BetterBuiltNW rep to earn points
6. Prizes awarded Friday to the top point earners
   - See “Challenge” section in the app for activities
7. Assistance available at the BetterBuiltNW table



Learning Objectives:
What you will be able to do

1. Differentiate benefits – VRF systems vs DHPs
2. Size and select the ideal VRF system
3. Design VRF systems - Duct design and ductless unit placement
4. Avoid control system mistakes

How Not to Get Snake Bit: The Design and Installation Process



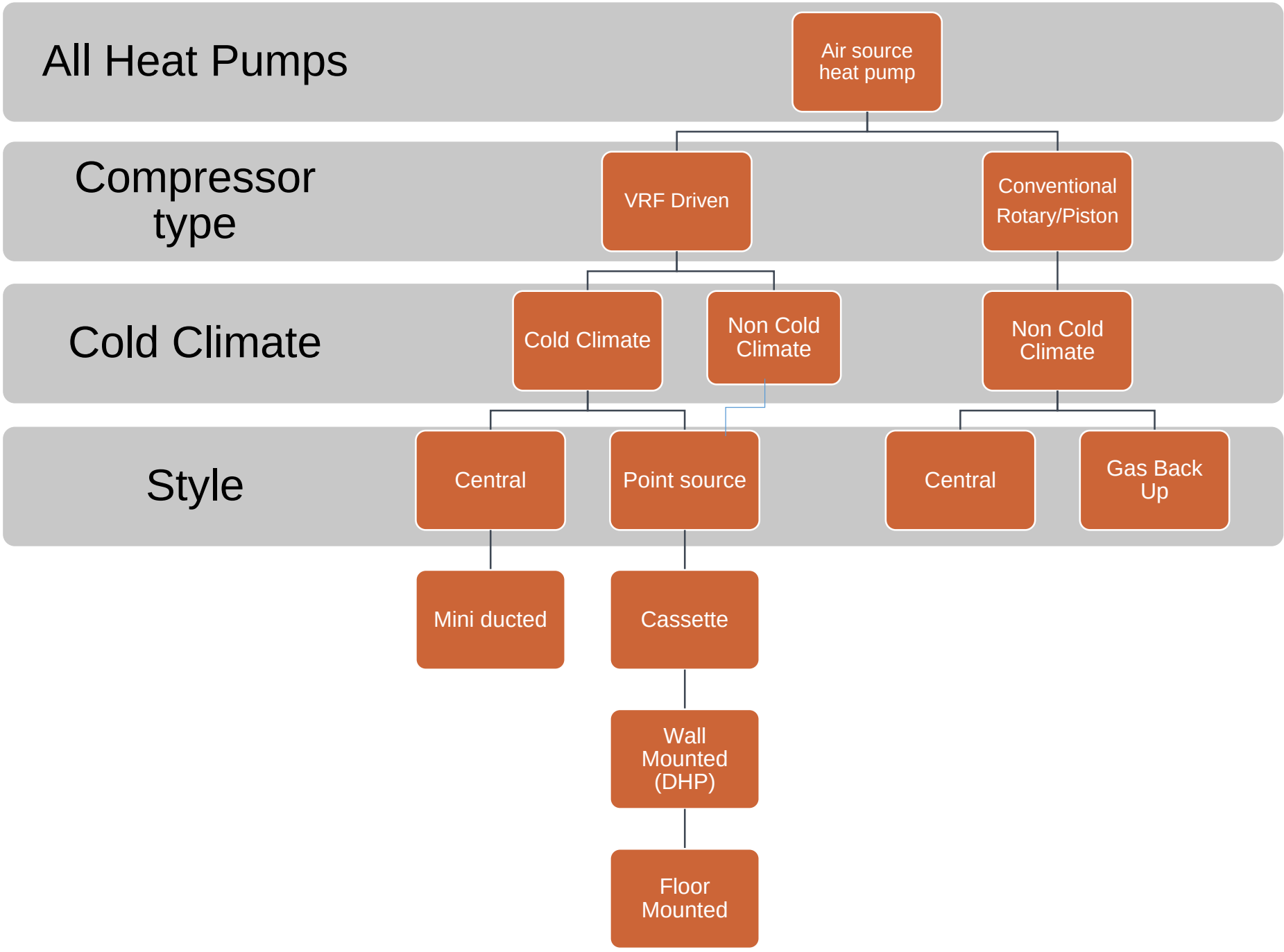
Differentiating Benefits – VRF systems vs non-VRF

Central Systems

- Conventional
- Variable Refrigerant Flow
- Ducted Mini-splits

Point-Source Systems

- Cassette
- Wall mounted (DHP)
- Floor mounted


All Heat Pumps
Compressor type
Cold Climate
Style
Air source heat pump
VRF Driven
Conventional Rotary/Piston
Cold Climate
Non Cold Climate
Non Cold Climate
Central
Point source
Central
Gas Back Up
Mini ducted
Cassette
Wall Mounted (DHP)
Floor Mounted

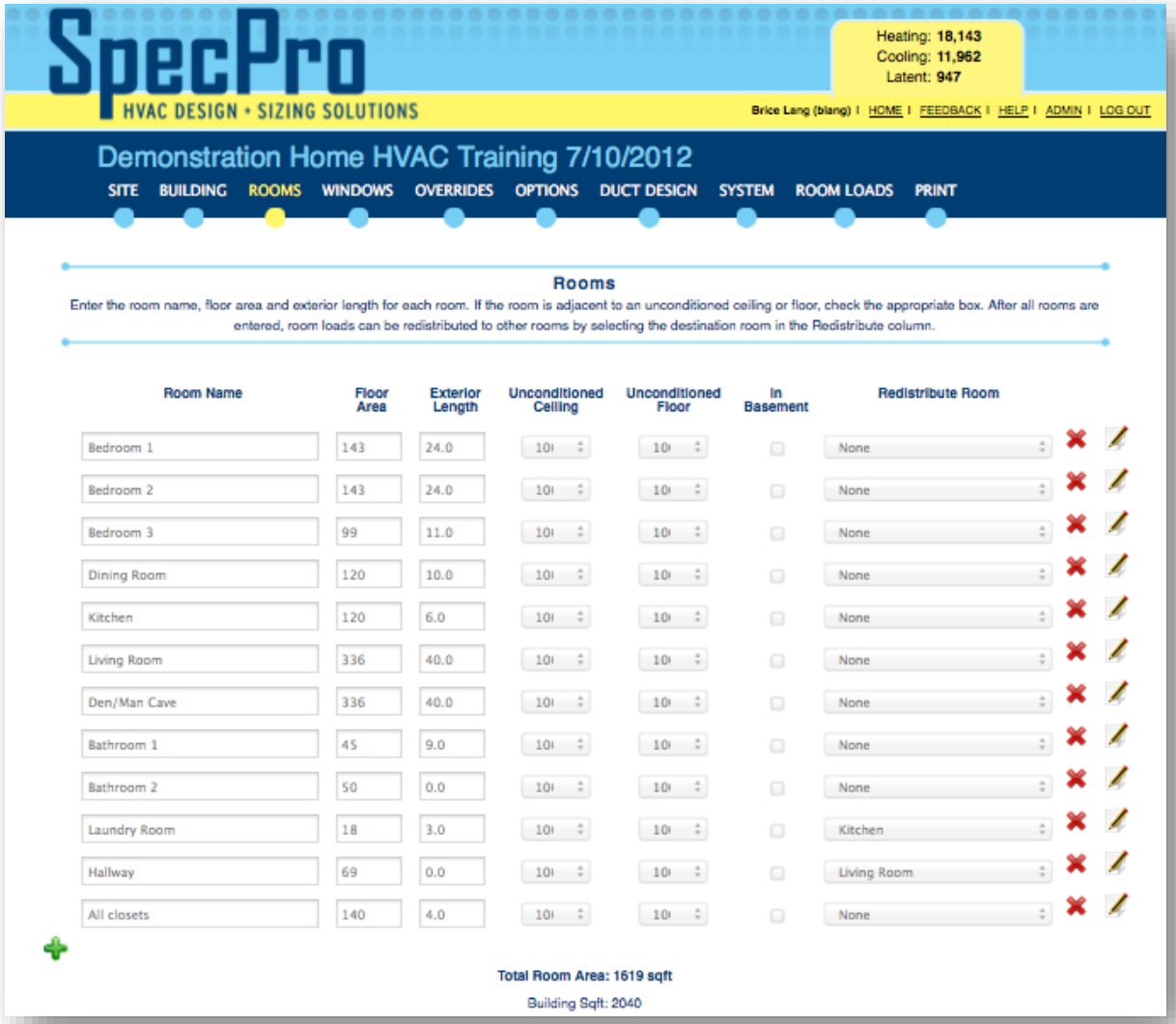
VRF Benefits

	Conventional HP	VRF HP	Cold Climate VRF HP
Variable Capacity	No	Yes	Yes
COP at 5F*	1.1	1.2	1.7
Noise*	60 dB	50 dB	50 dB
Capacity at 5Degress*	25%	50%	100%

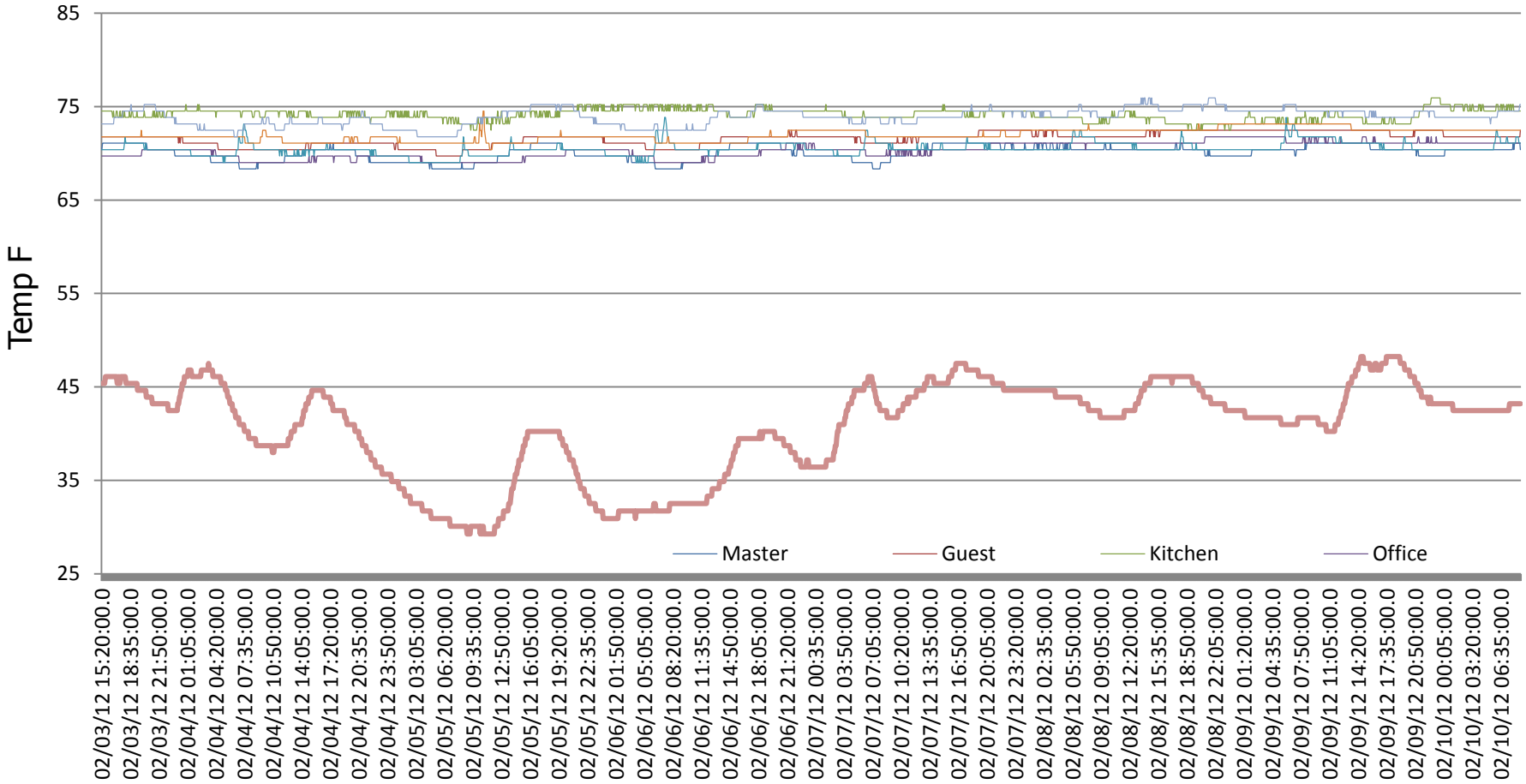
*Typical Values - there are exceptions in all categories

Room by Room Loads

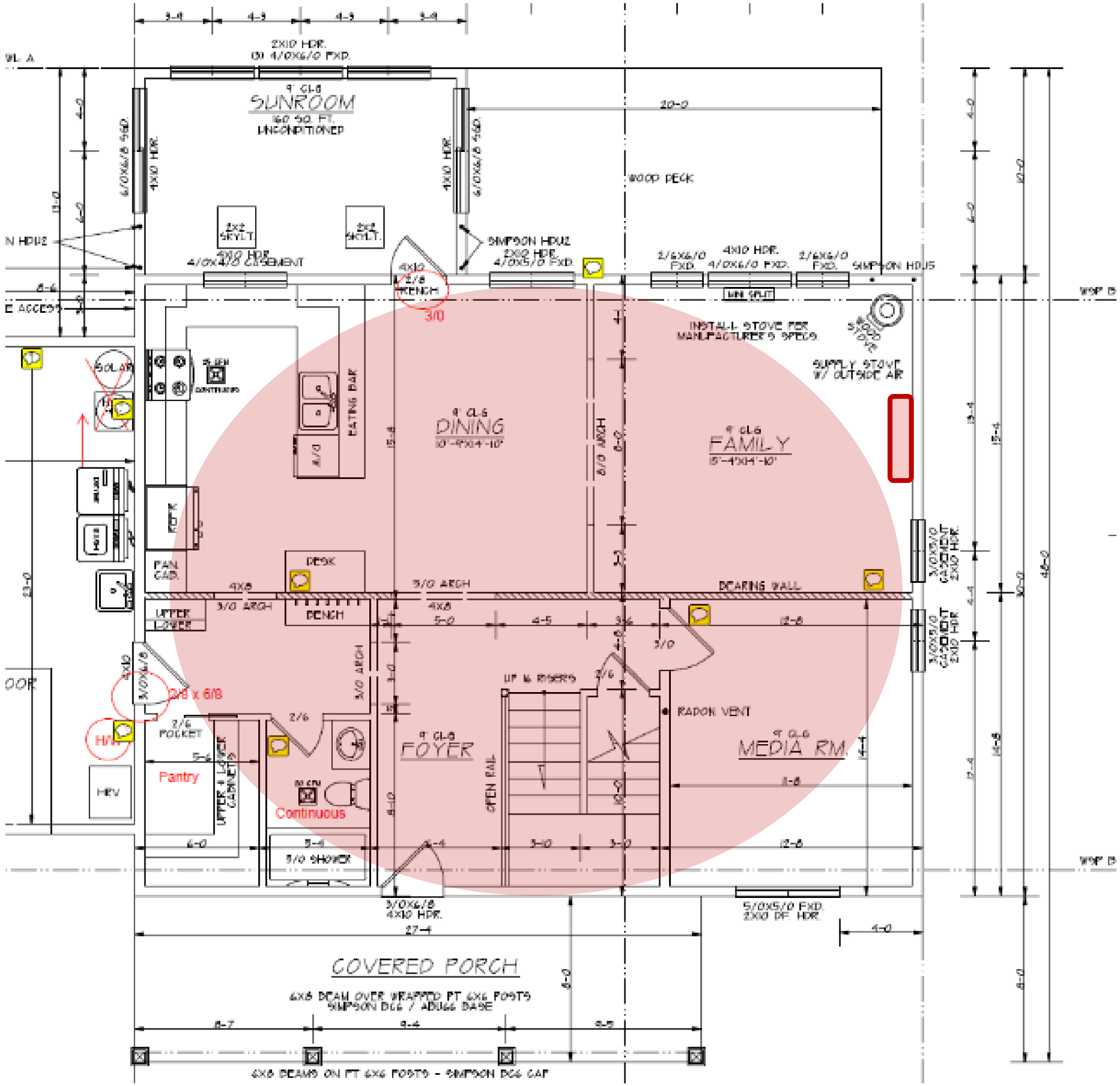
- If a room has 15% of the load, it needs 15% of the capacity
- Without knowing the room by room heating and cooling loads, you can't size the system



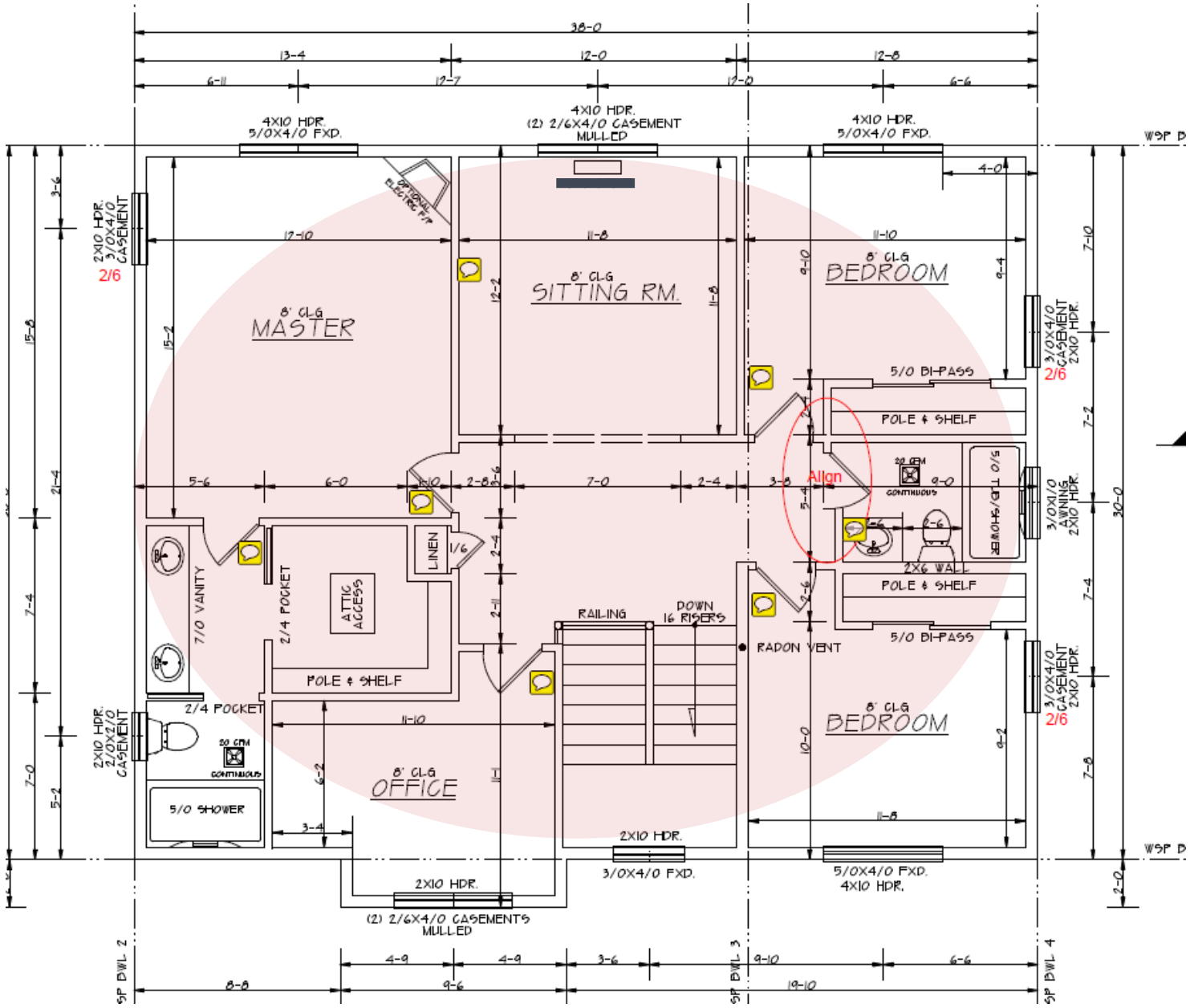
2,200 Sq. ft. House with a 12K DHP



House has low UA. Very tight. 12K ductless heat pump and low-efficiency ERV. About 900 kWh/year for space heat.

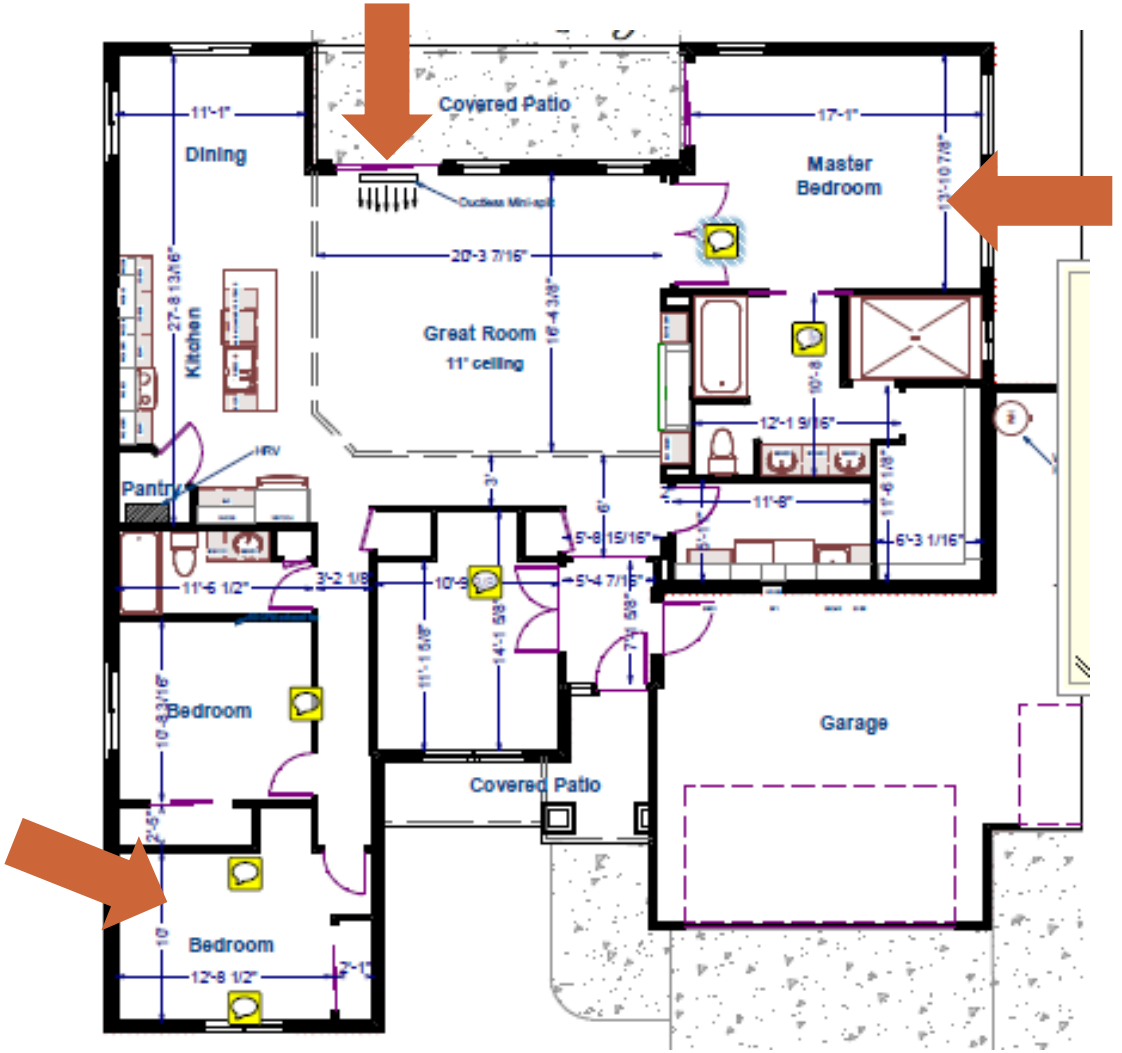


SUNROOM
160 SQ. FT.
UNCONDITIONED
WOOD DECK
SOLAR
DINING
10'-9"X14'-10"
FAMILY
15'-4"X14'-10"
INSTALL STOVE PER MANUFACTURER'S SPECS.
SUPPLY STOVE W/ OUTSIDE AIR
DESK
BENCH
BEARING WALL
EATING BAR
PAN CAD.
UPPER LOWER
FOYER
MEDIA RM.
UP 16 RISERS
RADON VENT
OPEN RAIL
5/0 SHOWER
HRV
H/W
Pantry
Continuous
3/0
2/8 x 6/8
COVERED PORCH
6X8 BEAM OVER WRAPPED PT 6X6 POSTS SIMPSON DCG / ADUGG BASE
6X8 BEAMS ON PT 6X6 POSTS - SIMPSON DCG CAP


38-0
13-4
12-0
12-8
6-11
12-7
12-0
6-6
4X10 HDR.
5/0X4/0 FXD.
4X10 HDR.
(2) 2/6X4/0 CASEMENT
MULLED
4X10 HDR.
5/0X4/0 FXD.
WSP D
2X10 HDR.
3/0X4/0
CASEMENT
2/6
OPTIONAL
ELECTRIC F/P
8' CLG
MASTER
8' CLG
SITTING RM.
8' CLG
BEDROOM
3/0X4/0
CASEMENT
2X10 HDR.
2/6
5/0 BI-PASS
POLE & SHELF
Align
50 CFM
CONTINUOUS
5/0 TUB/SHOWER
3/0X1/0
AWNING
2X10 HDR.
2X6 WALL
POLE & SHELF
5/0 BI-PASS
7/0 VANITY
2/4 POCKET
ATTIC
ACCESS
LINEN
1/6
RAILING
DOWN
16 RISERS
RADON VENT
2/4 POCKET
POLE & SHELF
2X10 HDR.
2X10/2/0
CASEMENT
50 CFM
CONTINUOUS
5/0 SHOWER
8' CLG
OFFICE
8' CLG
BEDROOM
3/0X4/0
CASEMENT
2X10 HDR.
2/6
2X10 HDR.
3/0X4/0 FXD.
5/0X4/0 FXD.
4X10 HDR.
2X10 HDR.
(2) 2/6X4/0 CASEMENTS
MULLED
WSP D
5P DWL 2
5P DWL 3
5P DWL 4
4-9
4-9
3-6
9-10
6-6
8-8
9-6
19-10

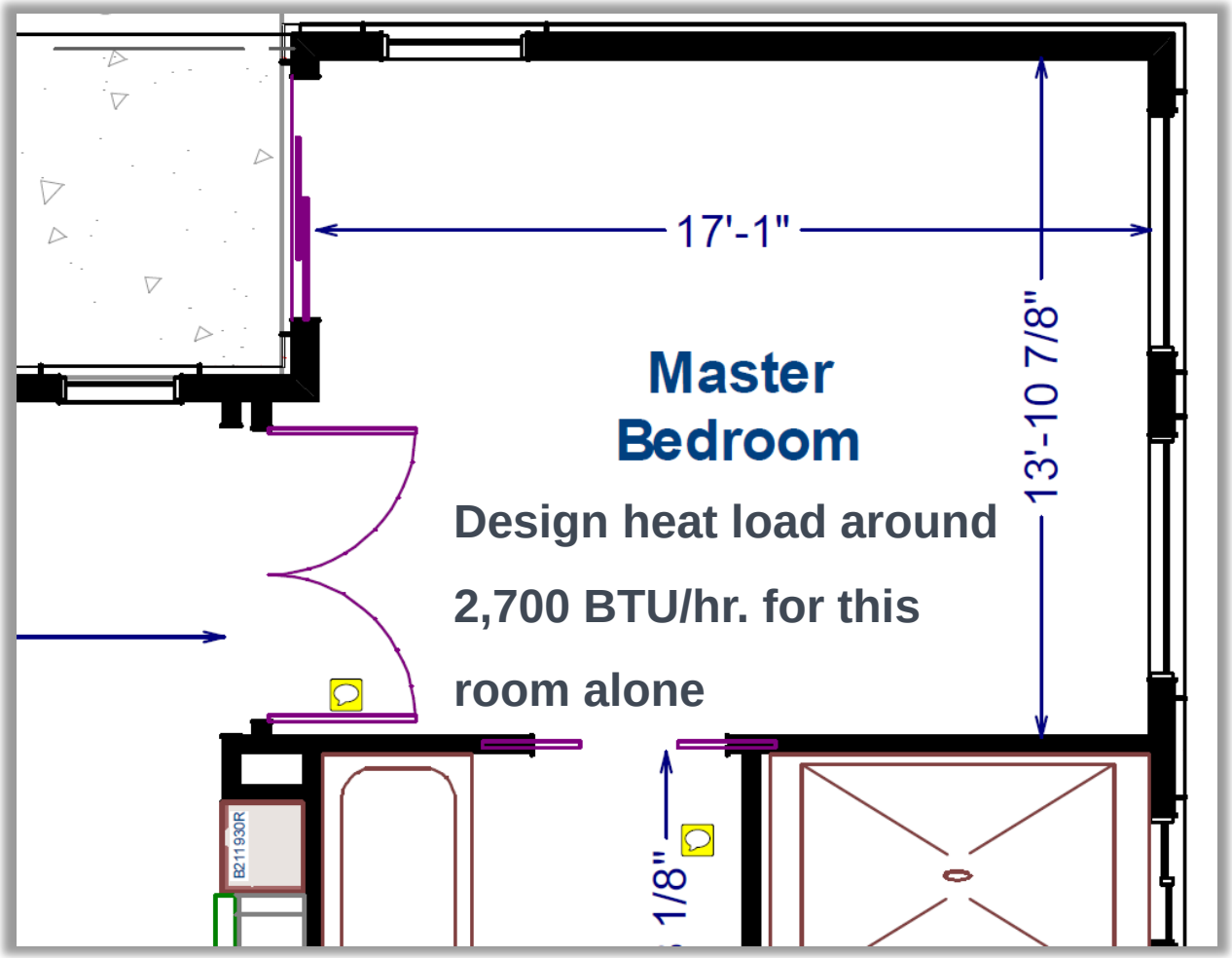
Home Geometry and DHP Performance

- Low Load House: 18K mini-split
- High Efficiency HRV
- What Could Go Wrong?



Home Geometry and DHP Performance

- Single Story Home
- 65 sq. ft. of glazing (26% of floor area
- Five surfaces exposed to exterior



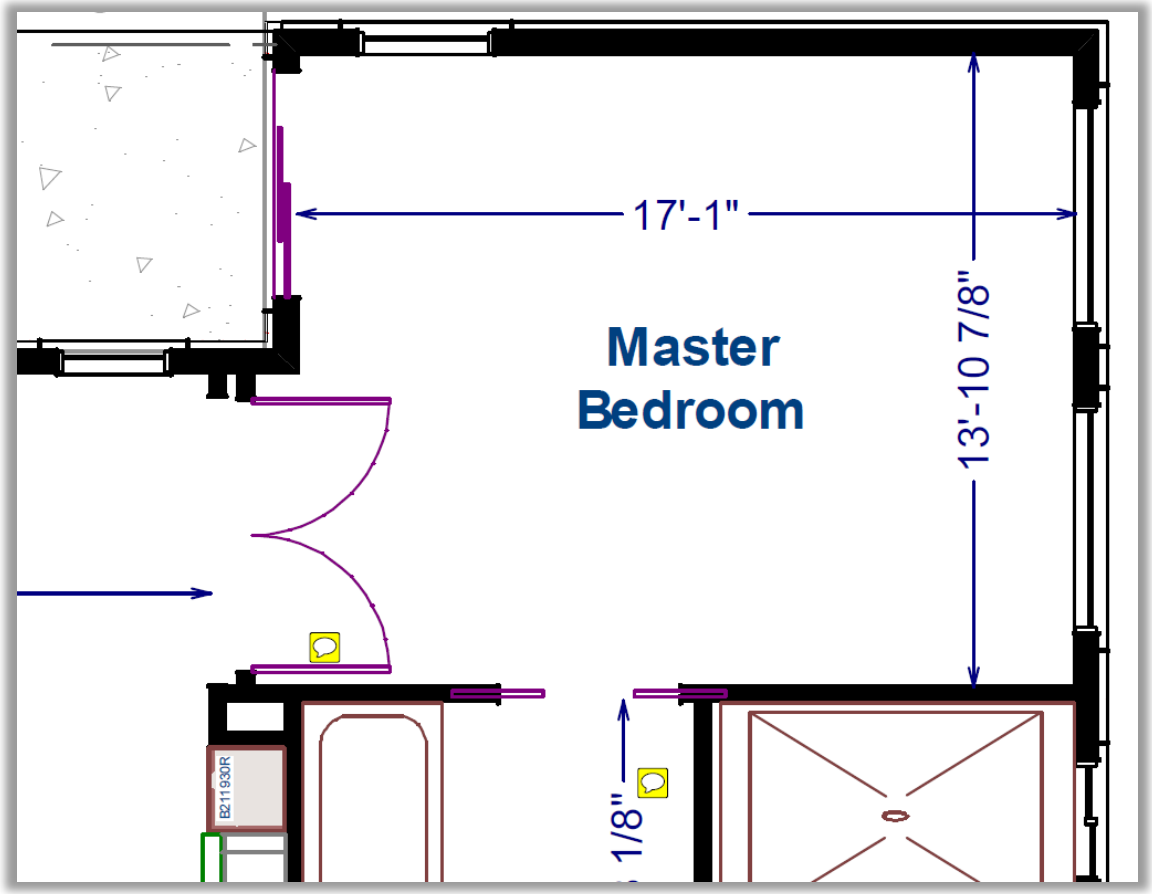
Home Geometry and DHP Performance

POP QUIZ

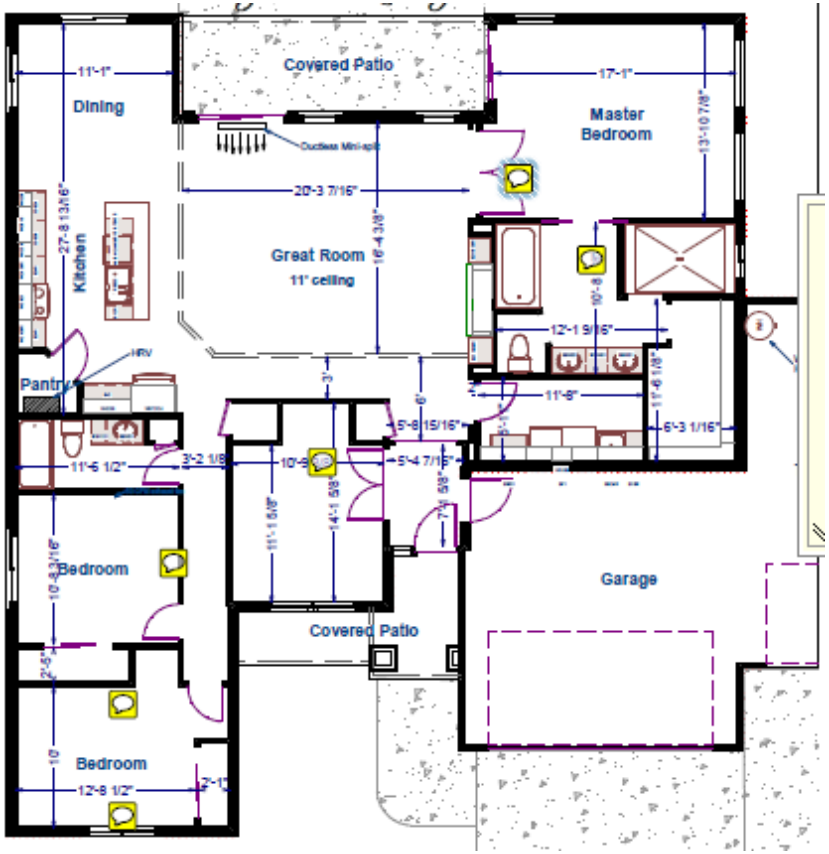
Q: How much 70° F air must you deliver to keep this room at or set point or 68 degrees?

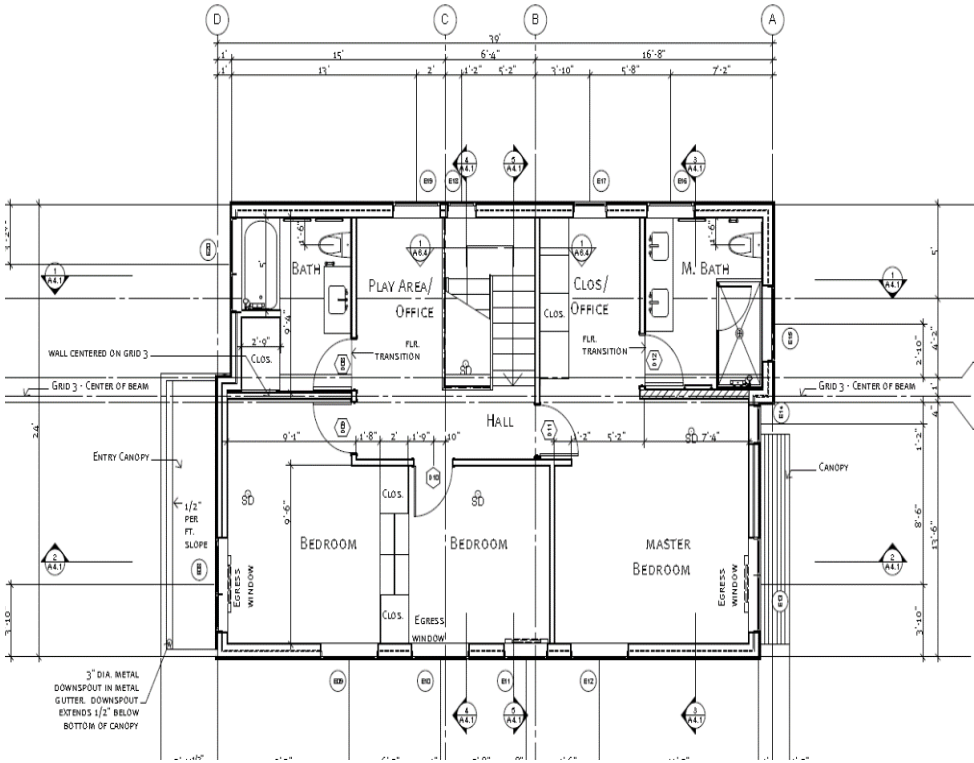
A: Too much

- Avoid creating thermally isolated rooms



Home Geometry and DHP Performance





Which home is best suited for a central air handler inverter driven heat pump and why?

Benefits

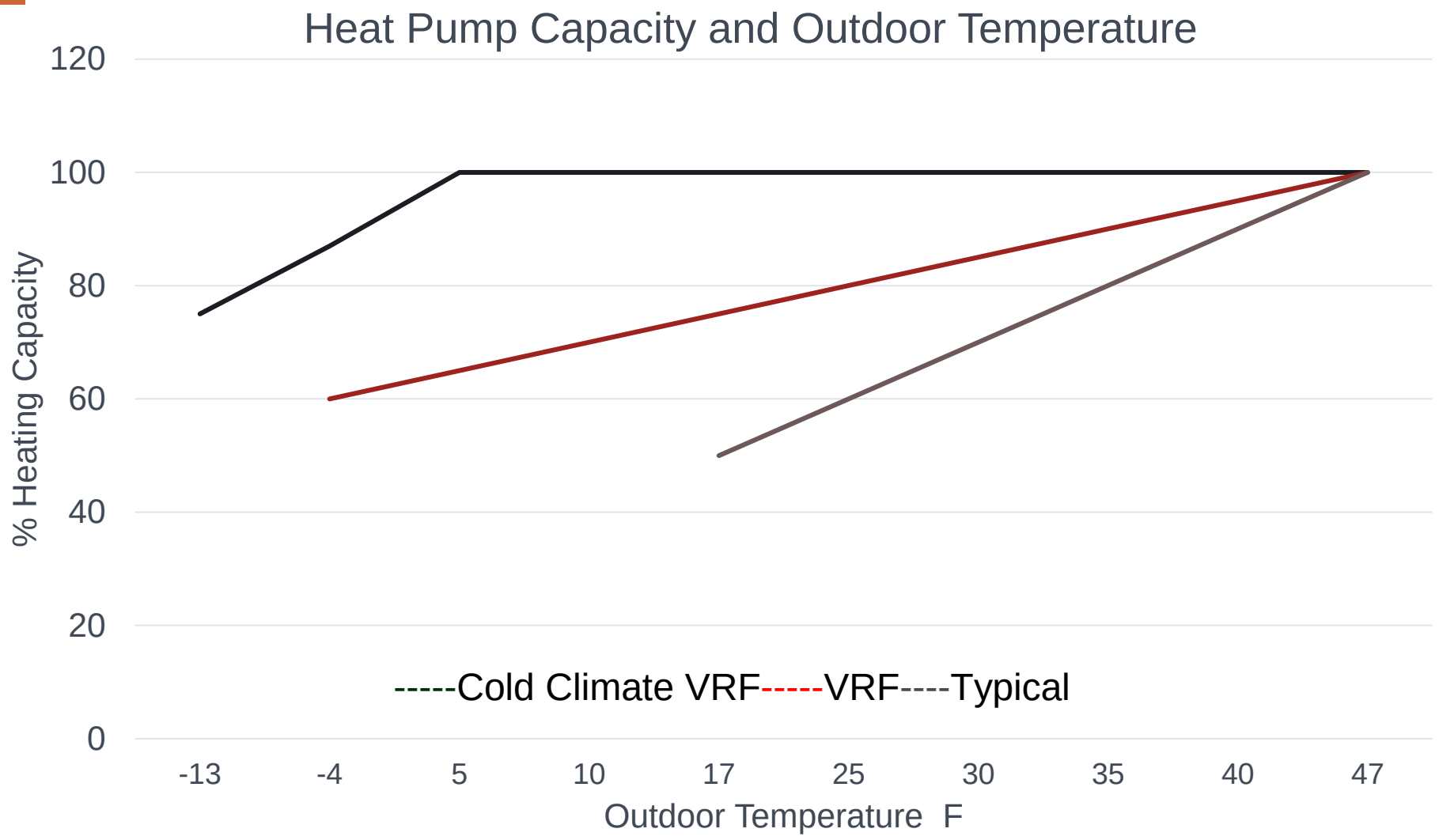
Turn to the person to your right and take turns answering the following question:

What are the benefits of a variable refrigerant flow HP vs. a standard heat pump?

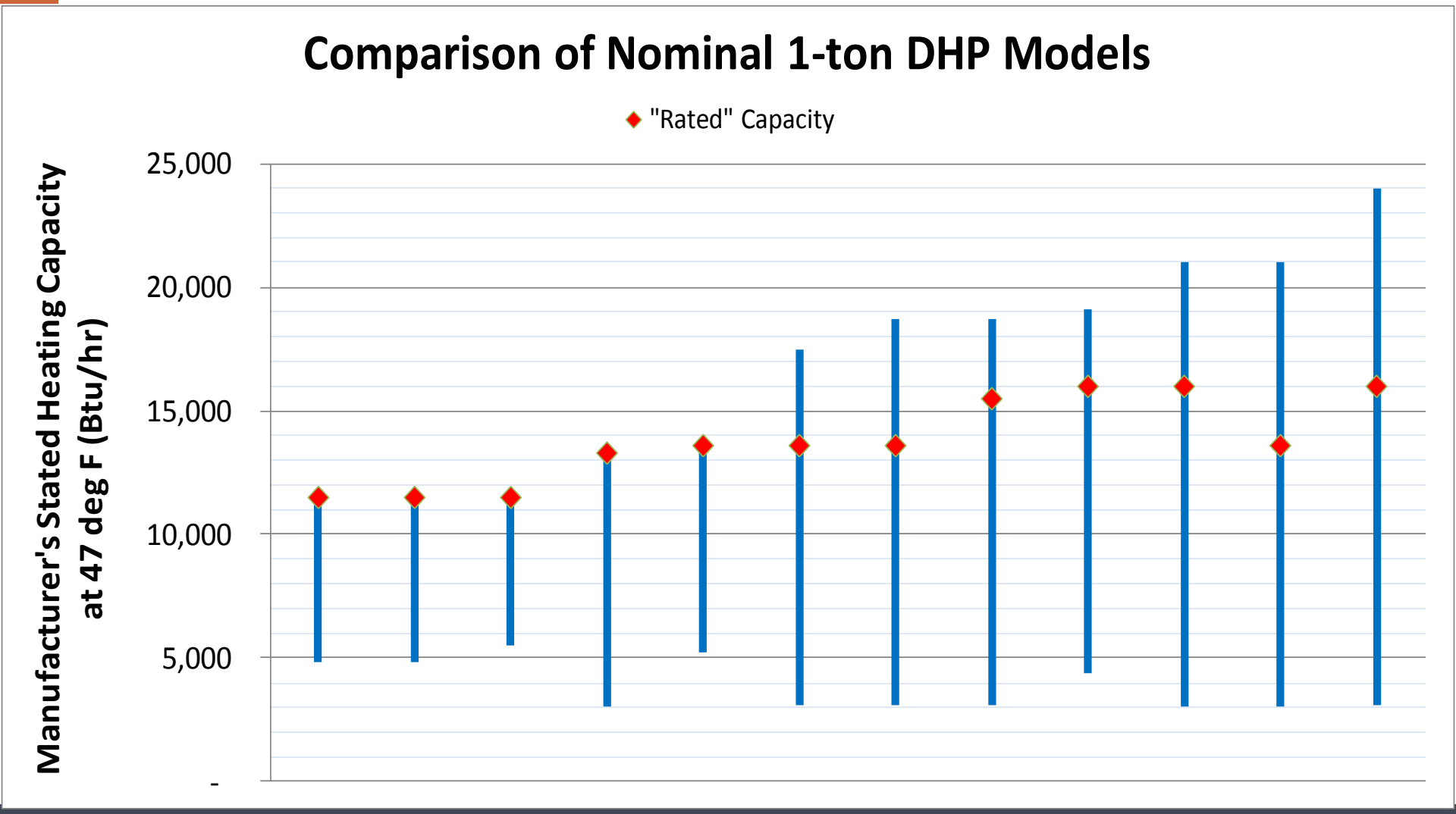
Comfortable customers if you do it right!

Size and Select The Ideal VRF System

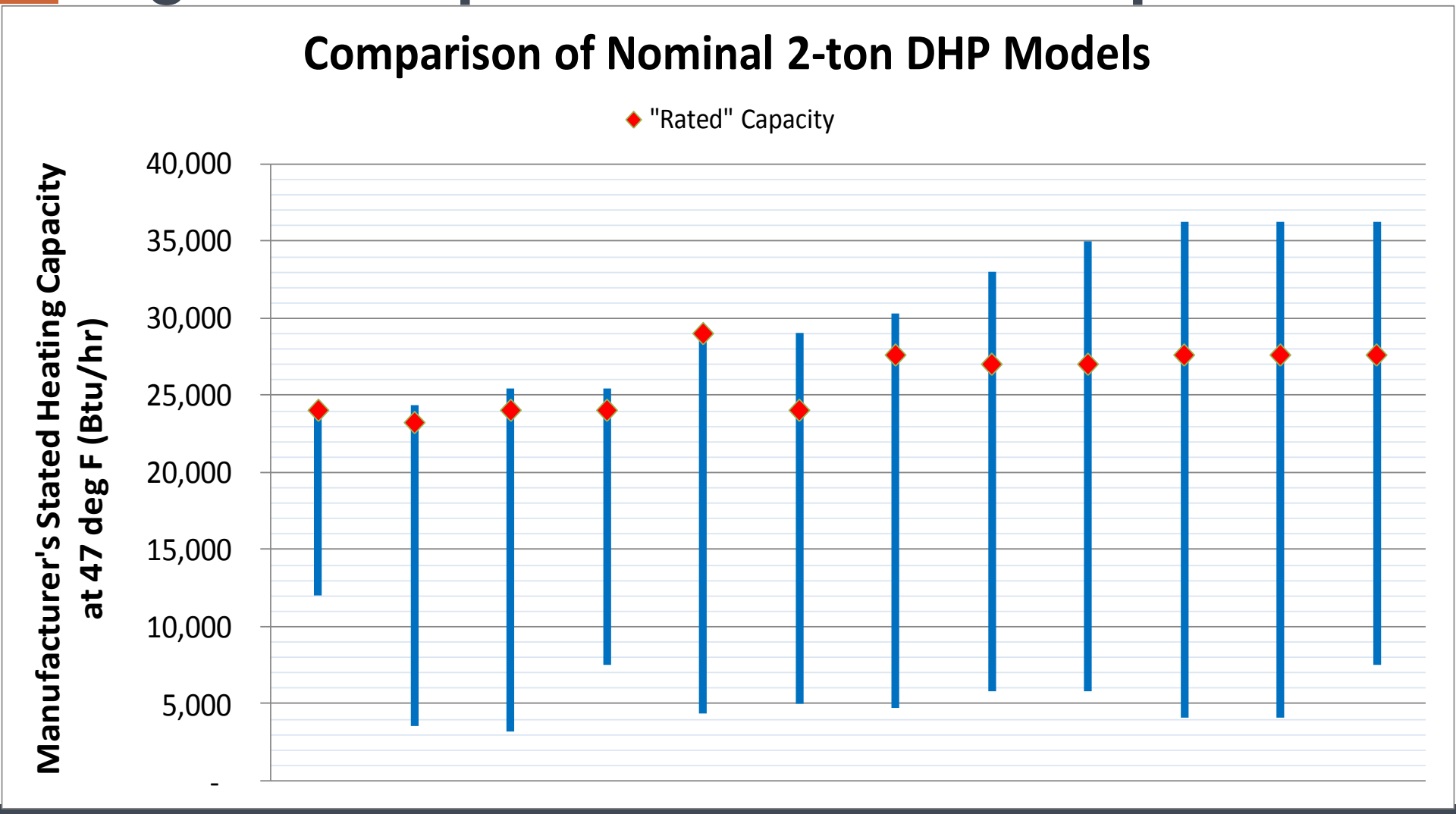
Sizing heat pumps



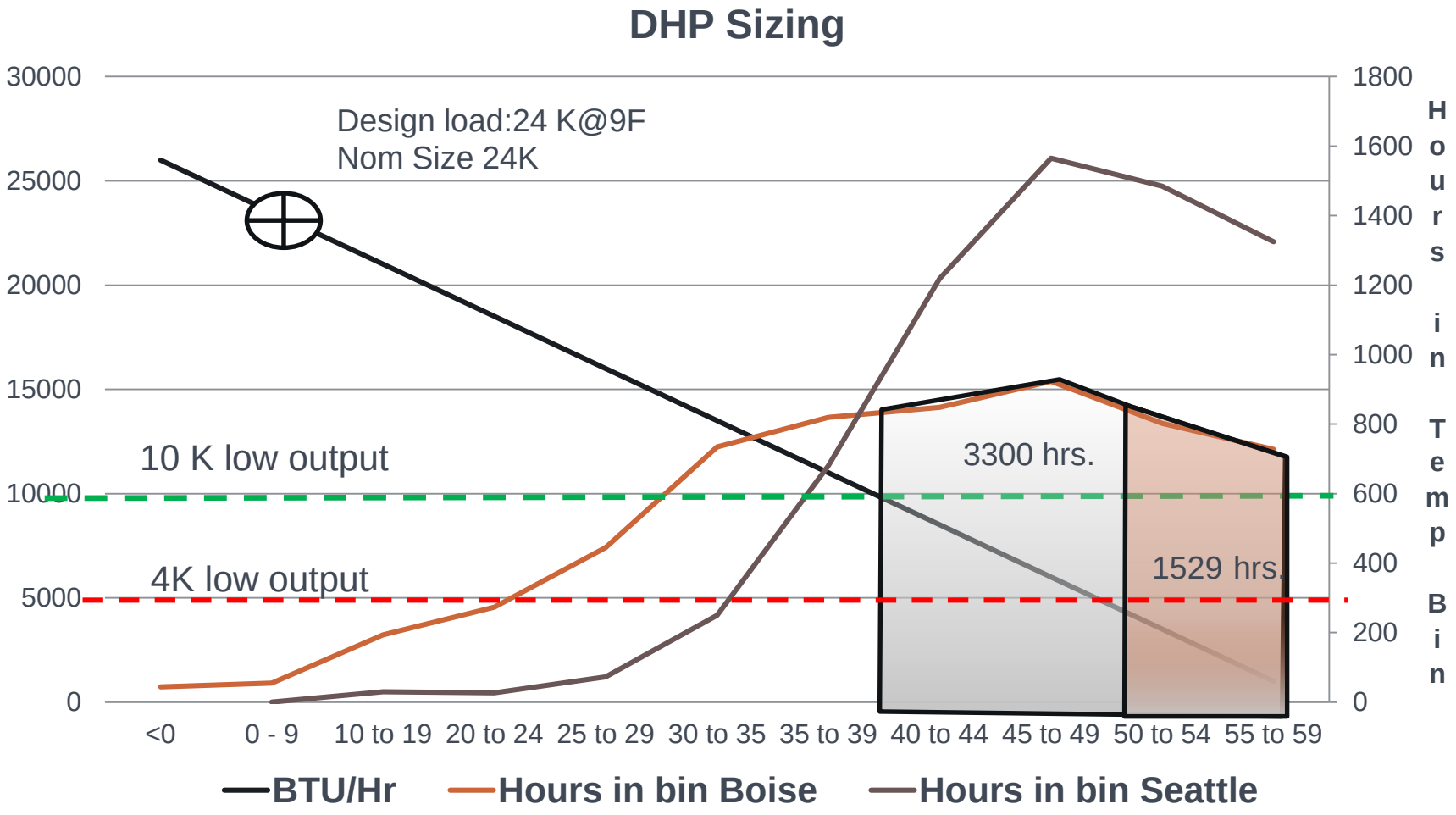
Tonnage: Ignore the Nominal Rating



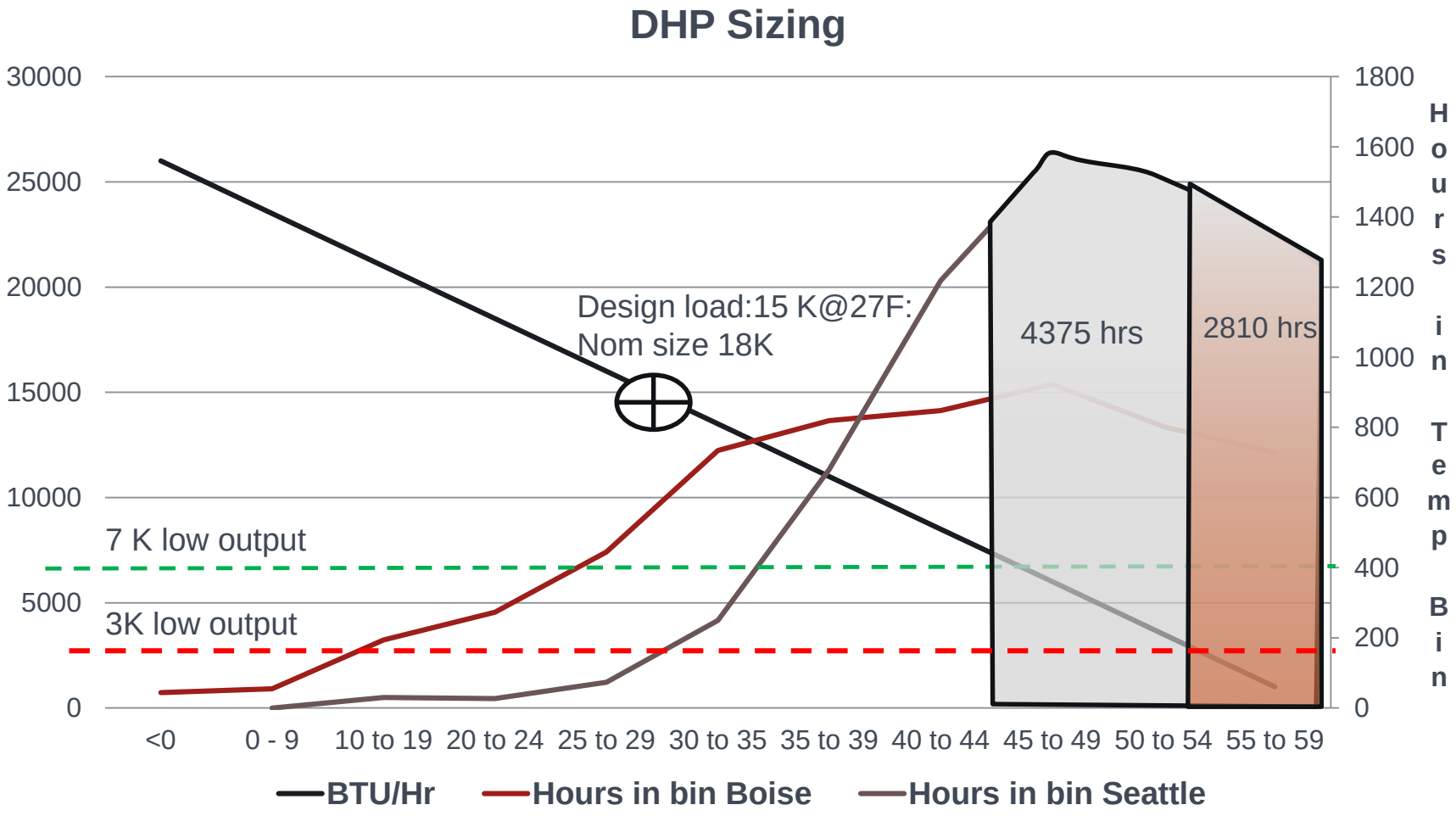
Turn Down Ratio: The ratio of the highest output to the lowest output



Why Turn Down Ratios Matter

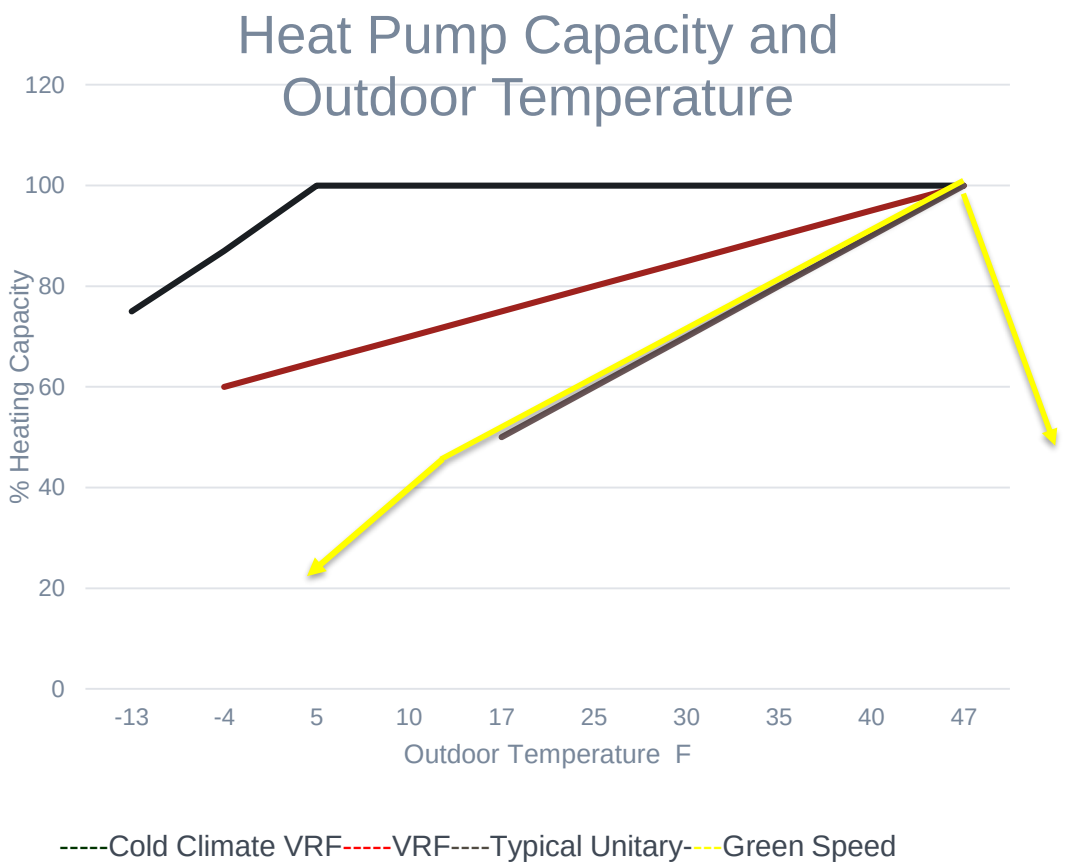


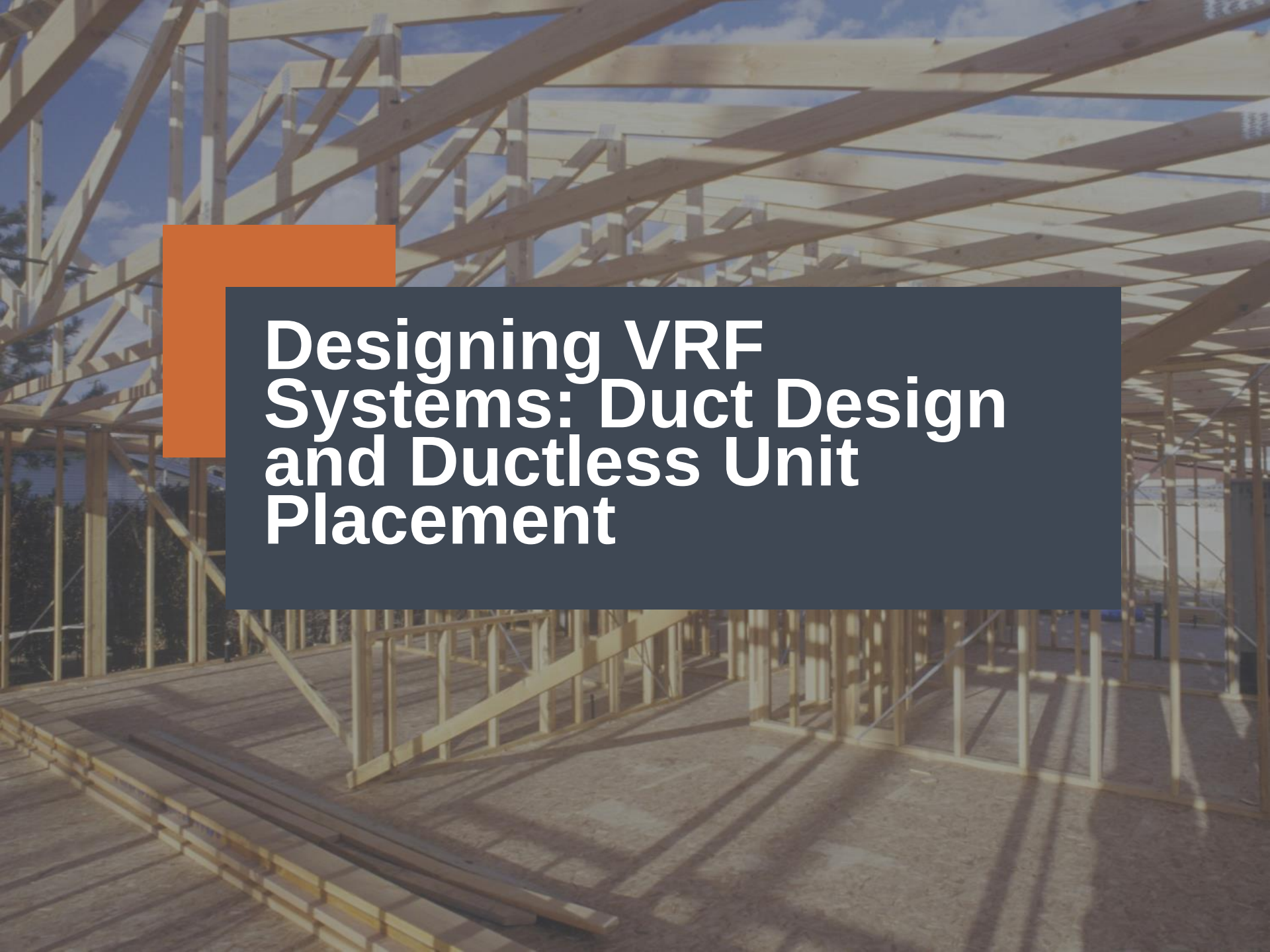
Mild Climates the Lowest Output is Extremely Important



Activity

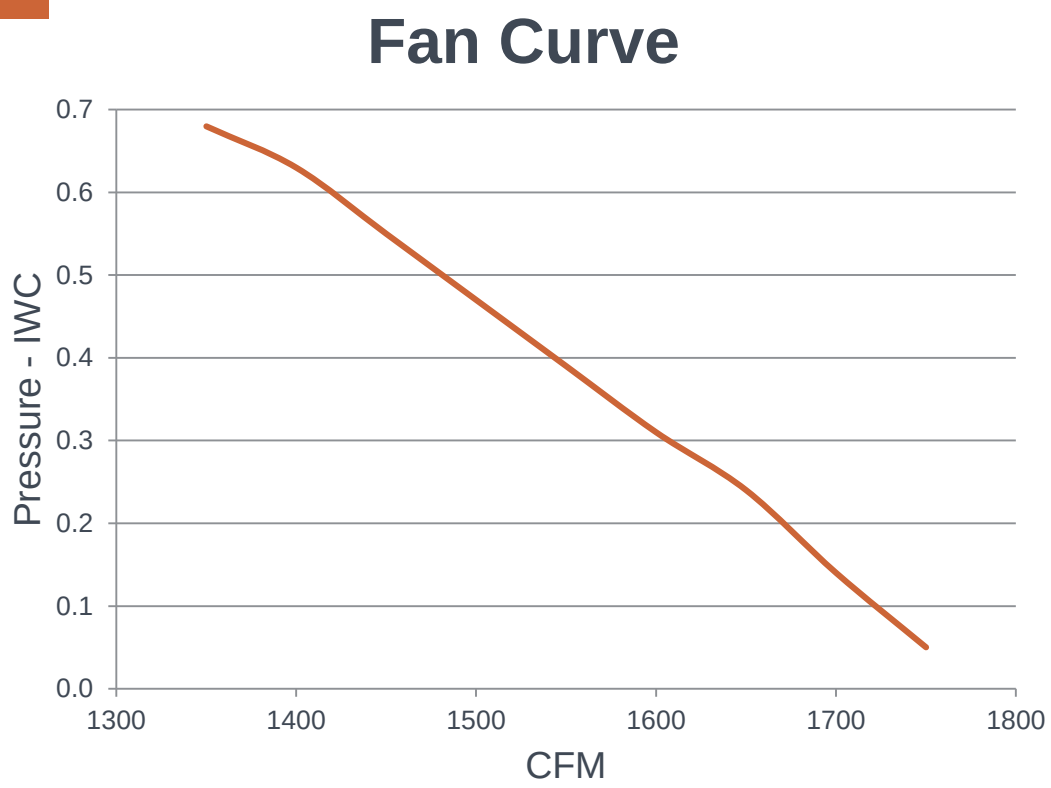
Why do you need capacity curves when sizing heat pumps?





Designing VRF Systems: Duct Design and Ductless Unit Placement

Distribution



Fans are the heart of the system.
They can break your heart, too.

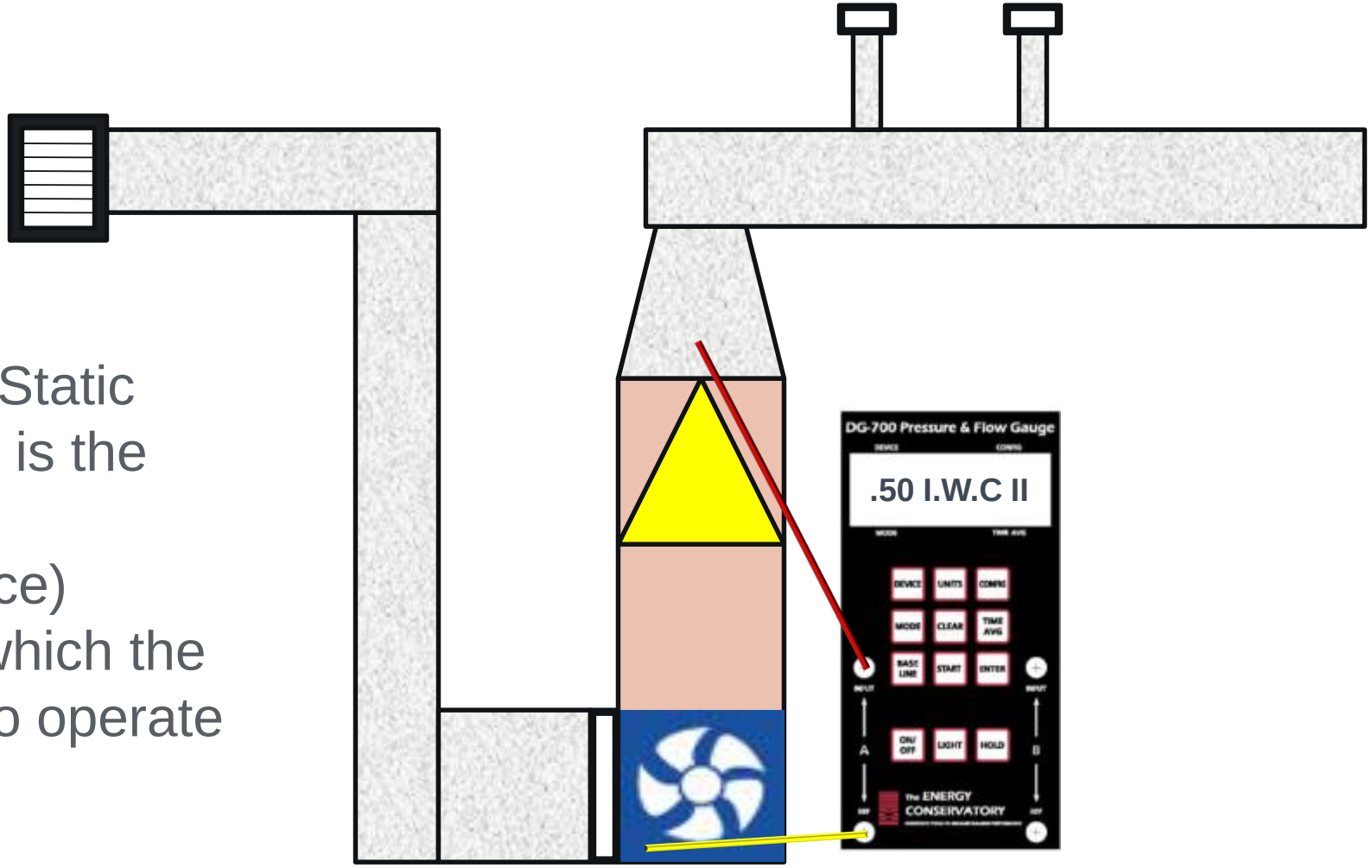
Fan Curve Table

AIR DELIVERY (Cfm) AT INDICATED EXTERNAL STATIC PRESSURE (With Filter)

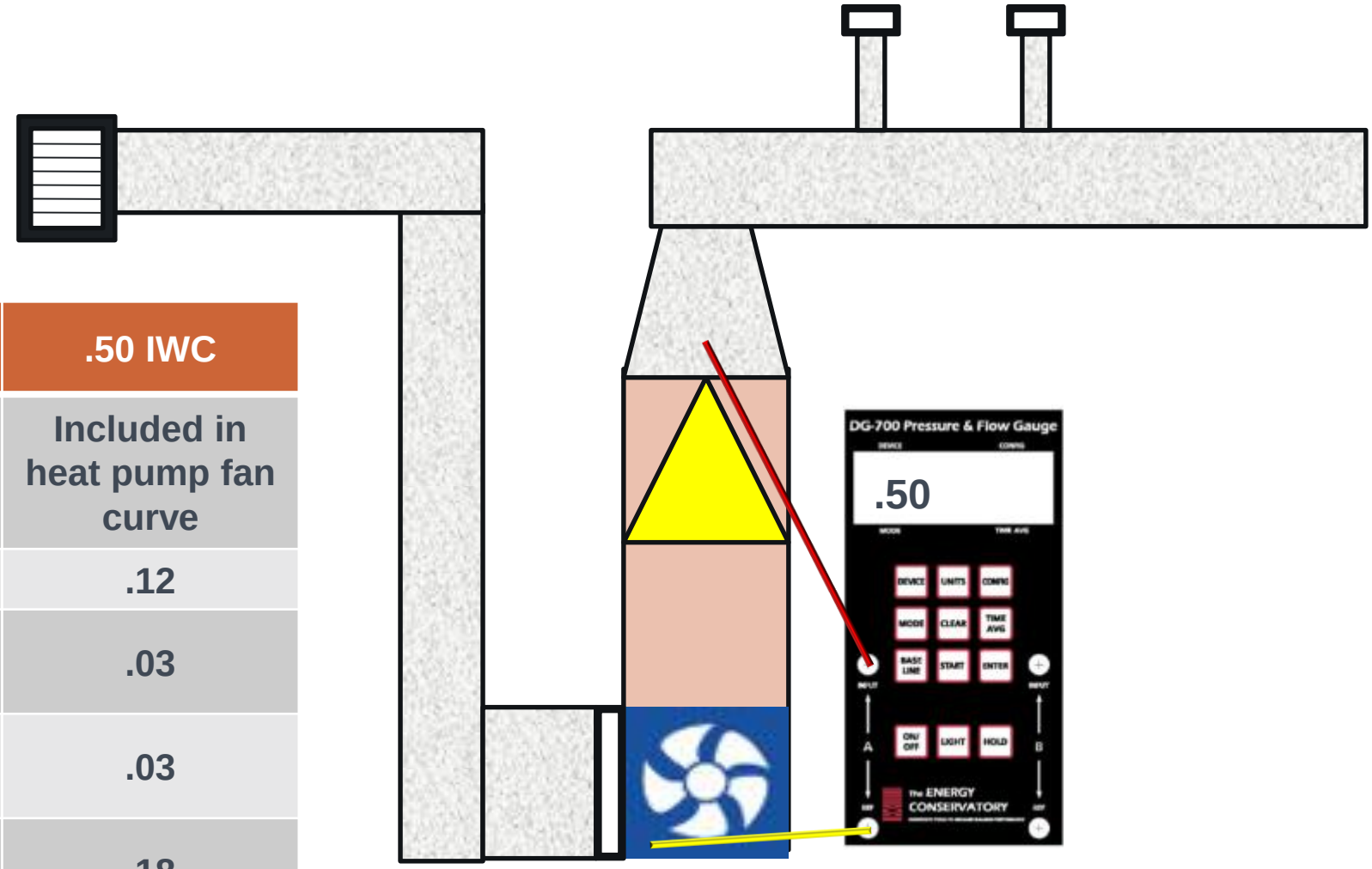
517E Size	Motor Speed Tap	Coil	External Static Pressure—Inches wc						
			0.1	0.2	0.3	0.4	0.5	0.6	0.7
042/043 (Without Heater)	High	Dry	1760	1700	1625	1535	1450	1350	1225
		Wet	1690	1625	1545	1455	1355	1260	—
	Medium	Dry	1615	1545	1490	1415	1345	1255	1150
		Wet	1545	1495	1435	1365	1275	1185	—
	Low	Dry	1435	1385	1340	1280	1210	1135	1035
		Wet	1395	1350	1300	1235	1165	1080	—
042/043 (With Heater)	High	Dry	1700	1635	1560	1475	1395	1290	—
		Wet	1625	1565	1485	1415	1320	1200	—
	Medium	Dry	1565	1505	1450	1385	1305	1215	—
		Wet	1510	1450	1390	1320	1235	1150	—
	Low	Dry	1410	1360	1315	1250	1180	1100	—
		Wet	1370	1325	1270	1205	1135	—	—
048/049 (Without Heater)	High	Dry	2075	1995	1910	1830	1745	1655	1550
		Wet	1950	1870	1795	1725	1645	1555	1455
	Medium	Dry	1900	1830	1765	1700	1625	1545	1450
		Wet	1810	1745	1685	1615	1540	1455	—
	Low	Dry	1710	1665	1615	1565	1510	1450	1370
		Wet	1660	1615	1565	1515	1450	1385	—

External Static Pressure (ESP)

External Static Pressure is the pressure (resistance) against which the fan has to operate

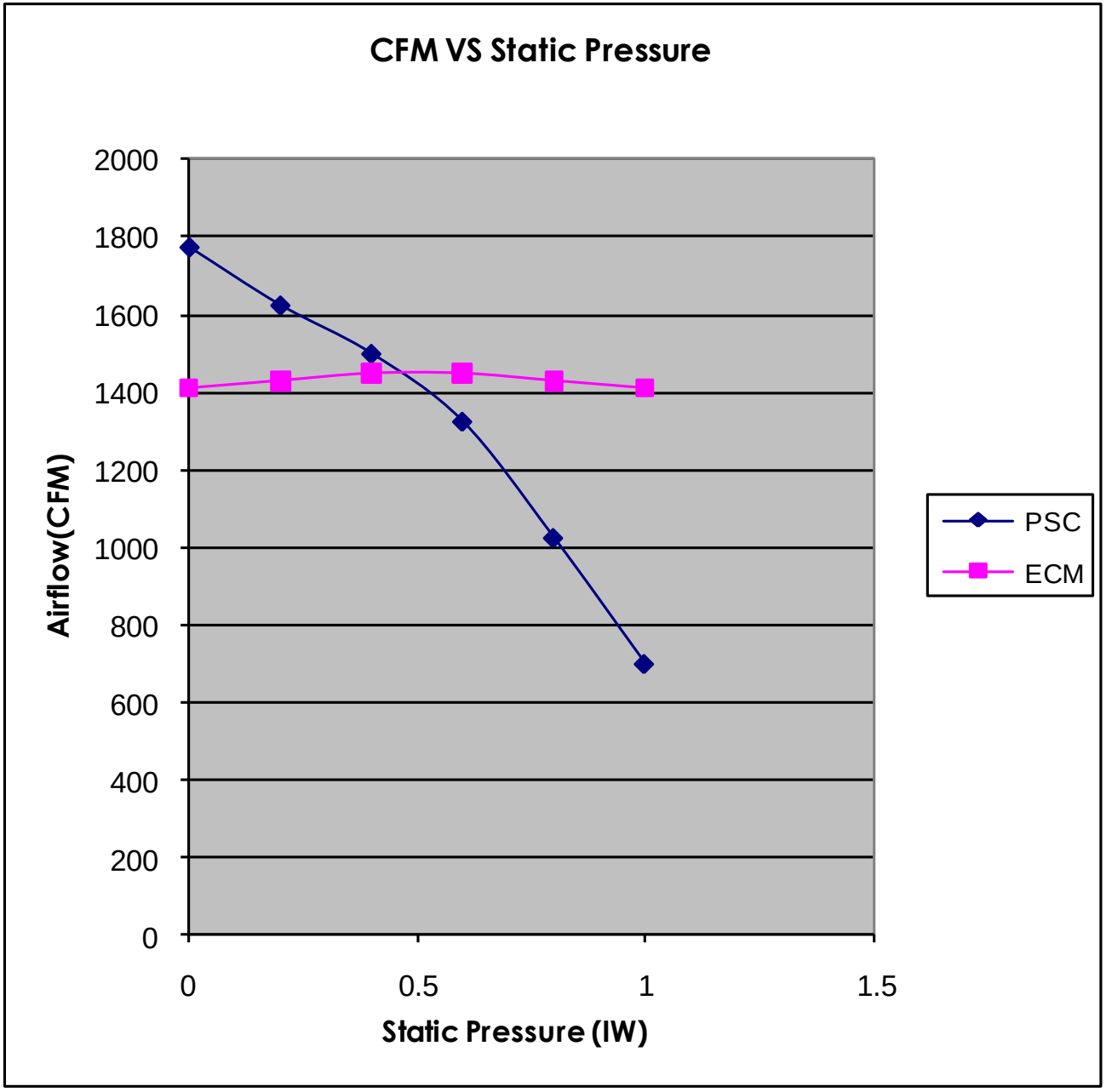


Total ESP	.50 IWC
Coil	Included in heat pump fan curve
Filter	.12
Return Grille	.03
Supply Grille	.03
Total Losses	.18
Available Static Pressure	.24 IWC

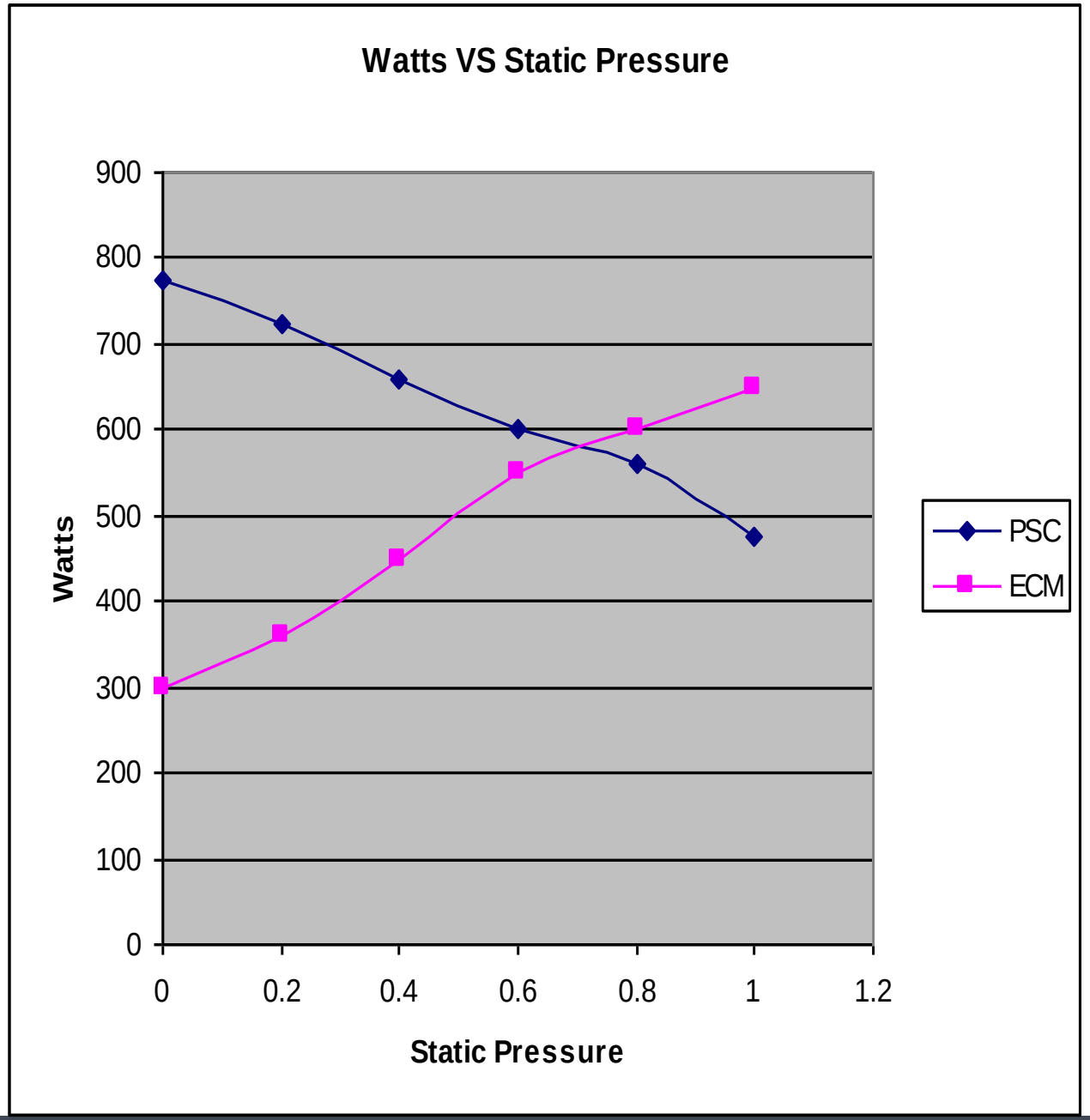


The available static pressure is the amount of pressure left over to overcome the resistance of the duct system. Coils and filters have large pressure drops.

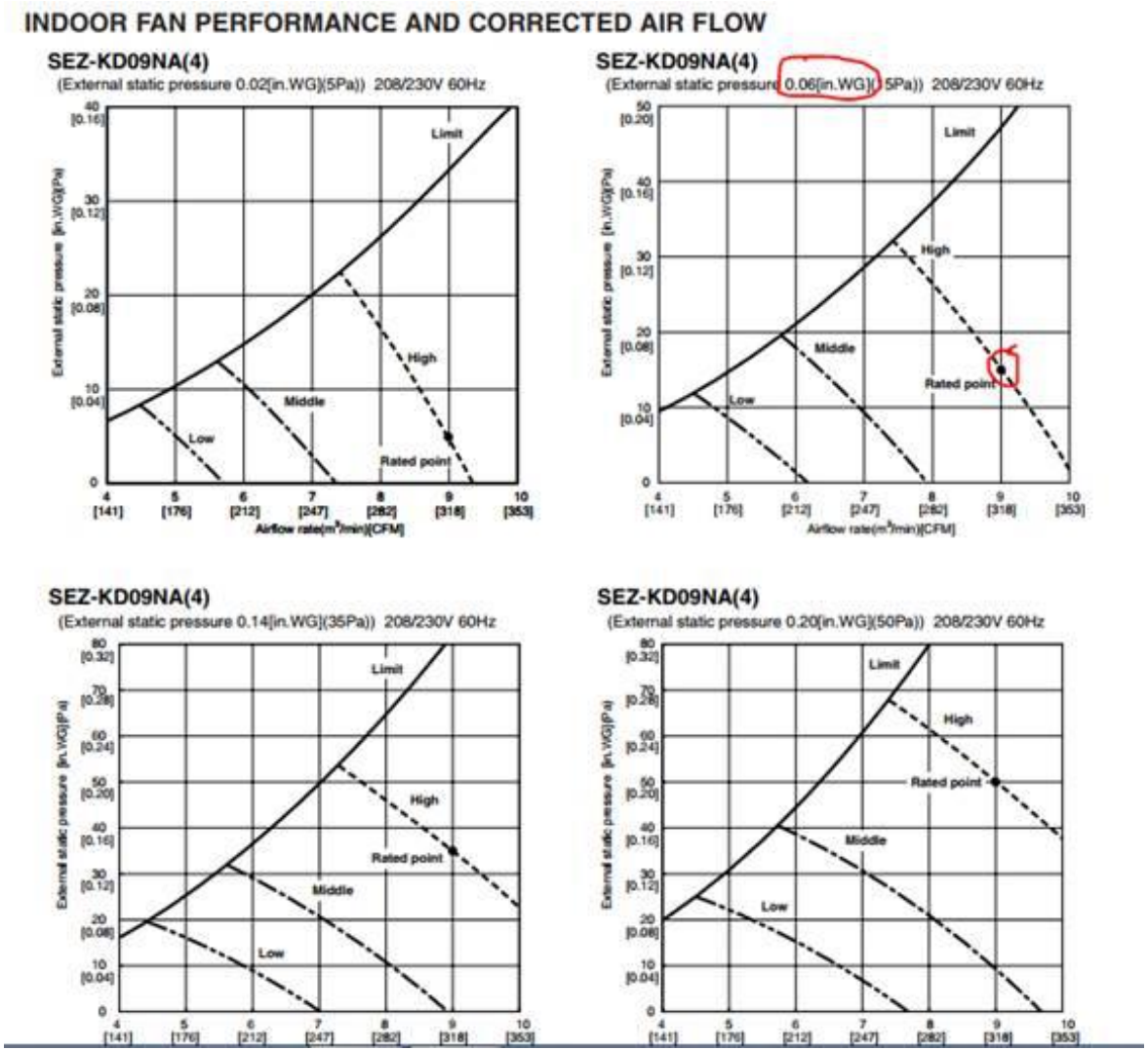
ECMs


CFM VS Static Pressure
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Airflow(CFM)
0
0.5
1
1.5
Static Pressure (IW)
PSC
ECM

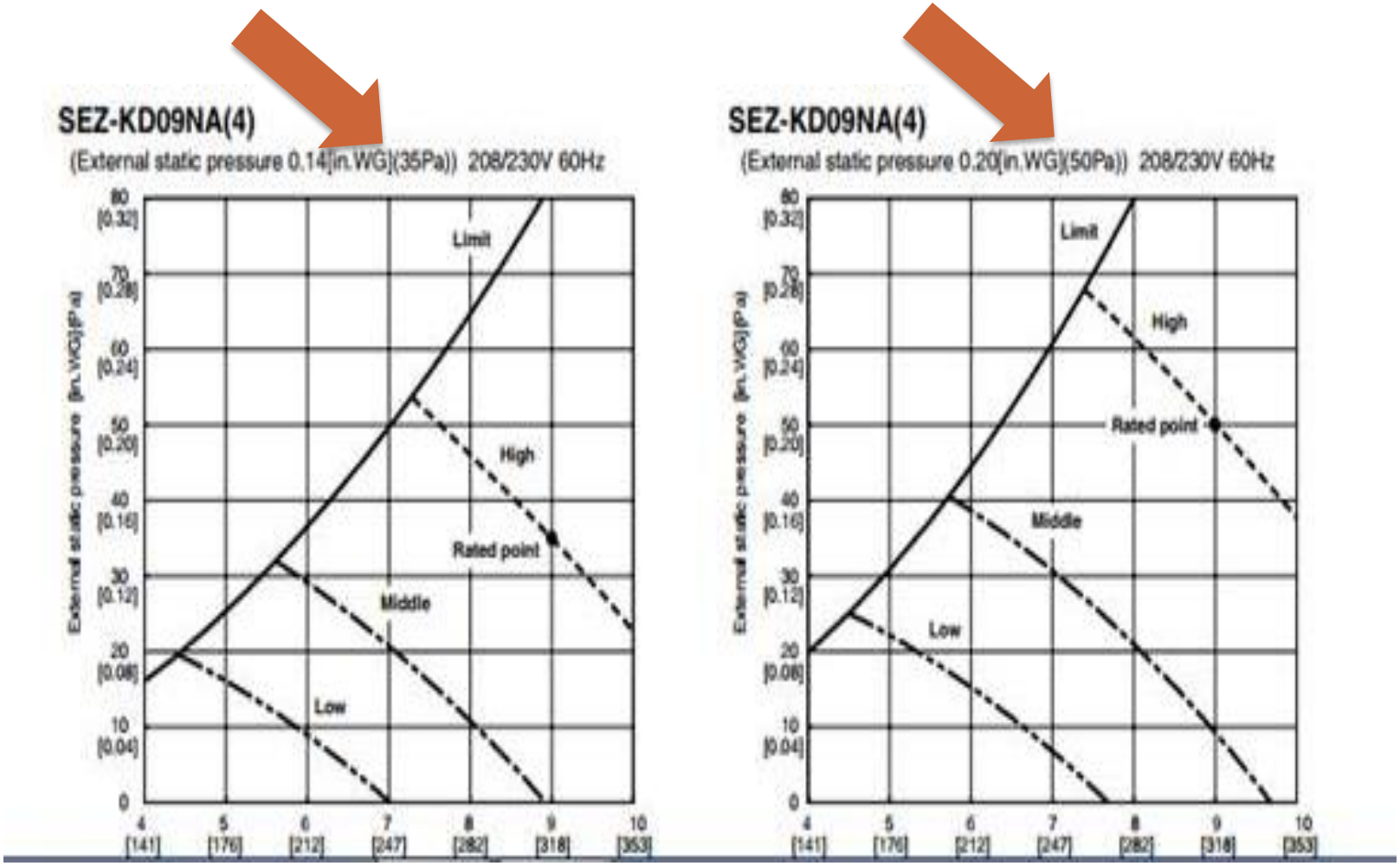
ECMs Are Not Magic



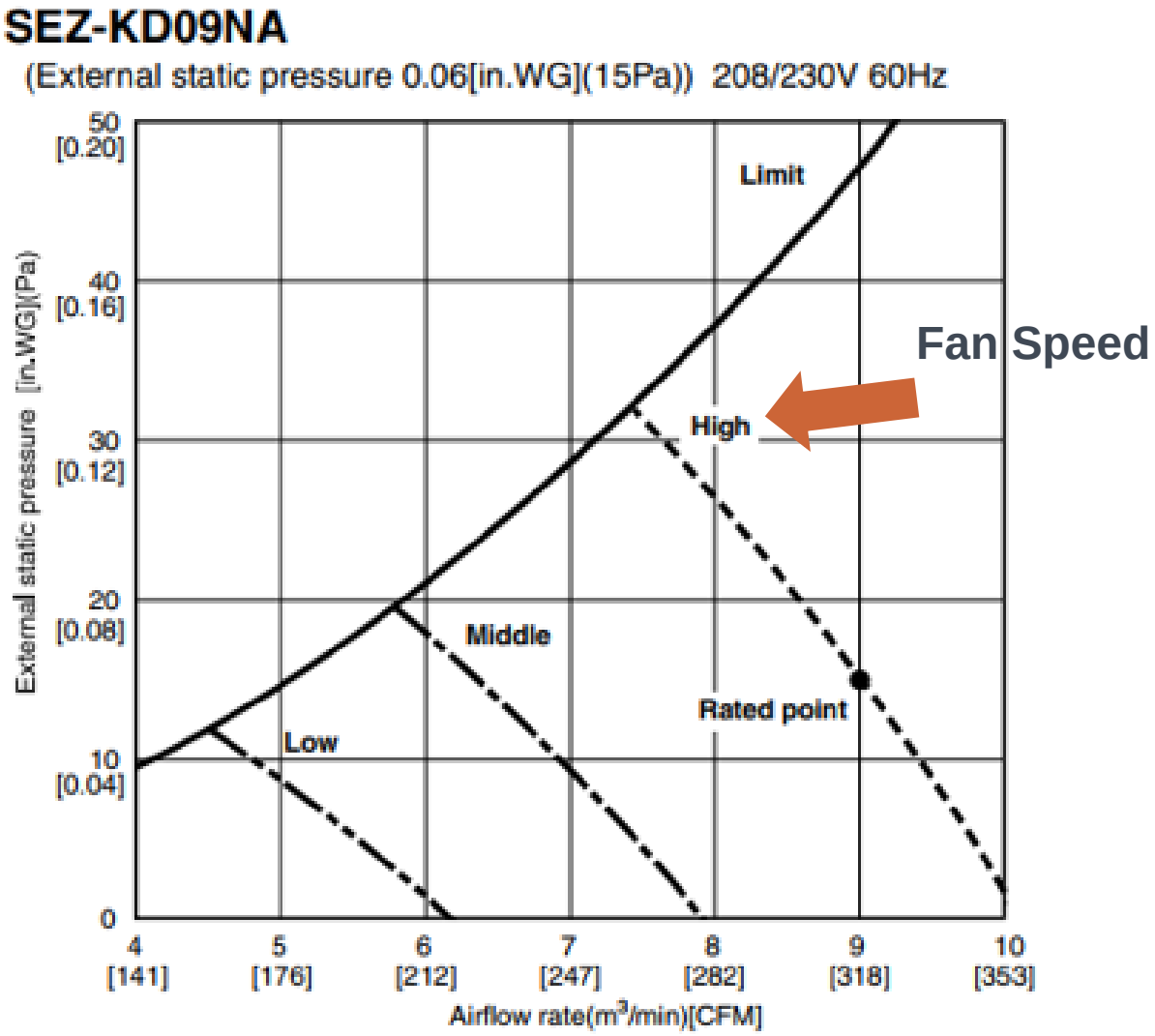
Why Four Fan Curves for One Unit?



This unit has four ESP settings with three fan speeds in each setting

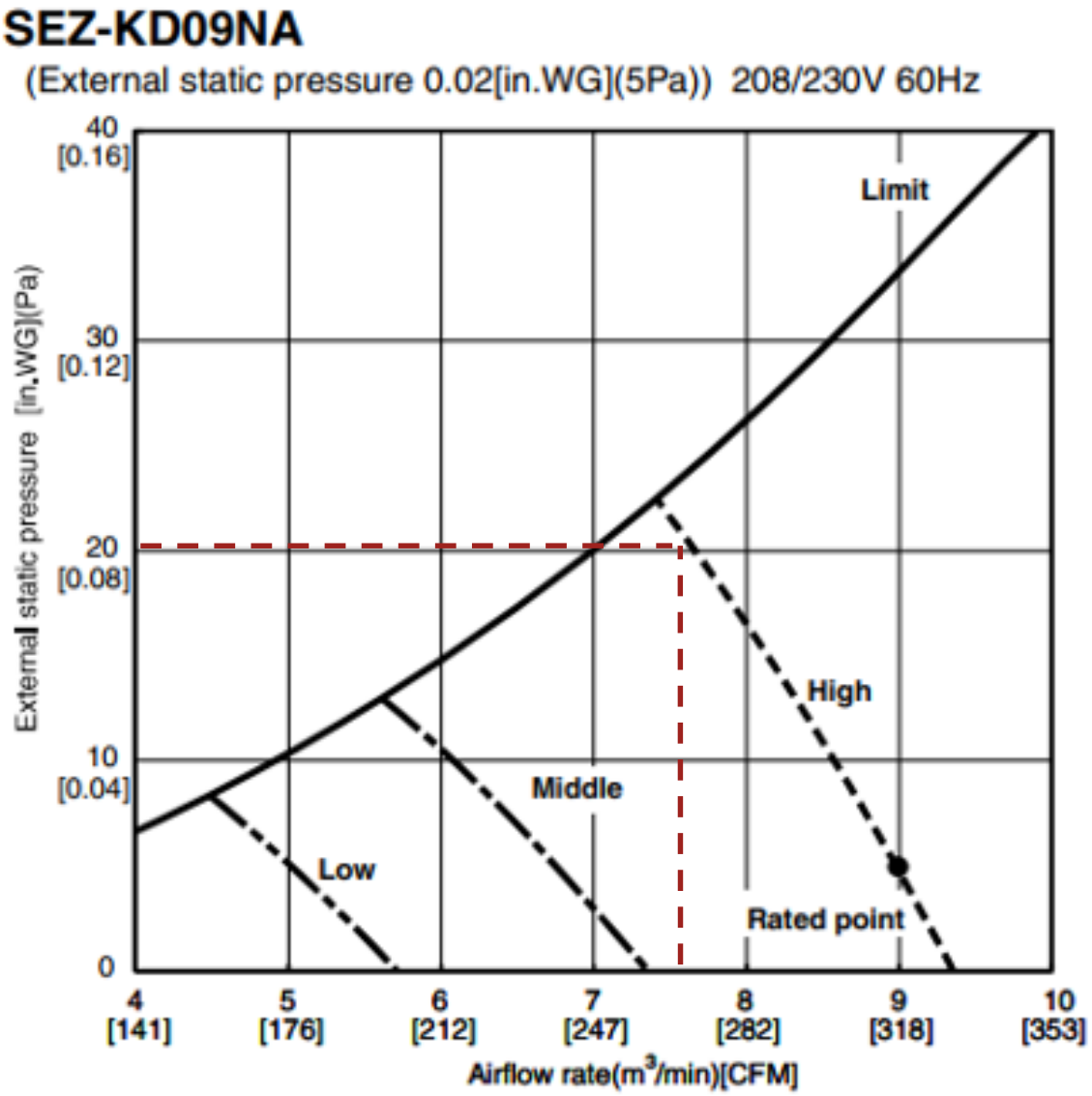


Low Profile VRF Fan Curve



Activity

What is the CFM in the ultra low ESP Setting at .08 I.W.C on high speed?



Moving air hates to make hard turns

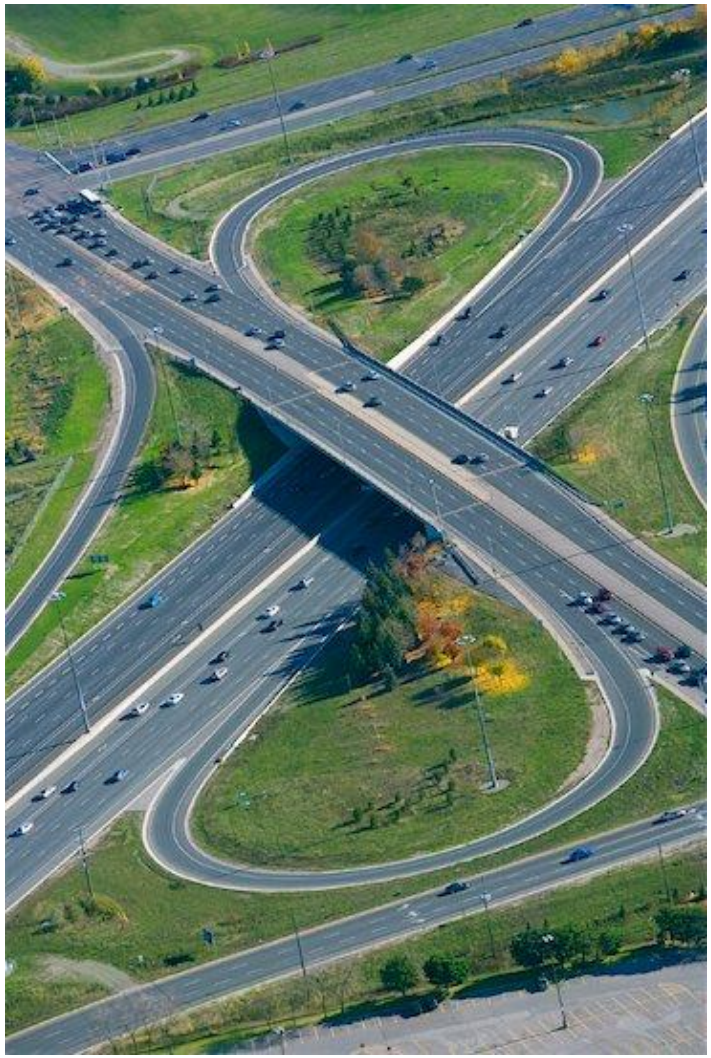


Photo credit: http://www.masterfile.com/stock-photography/image/600-01791391/Aerial-View-of-Freeway-Intersection-Highway-404-and-Finch-Avenue-Willowdale-Ontario-Canada

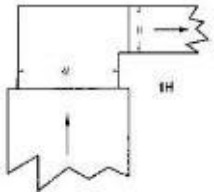
Relax: We will show you a short cut

- Step 1: Calculate the Total Equivalent Length (TEL)
- Step 2: Calculate the Available Static Pressure
- Step 3: Calculate the Friction Rate
- Step 4: Determine how much air each duct section is carrying
- Step 5: Size the ducts

Comparison of Equivalent Lengths (ELs)

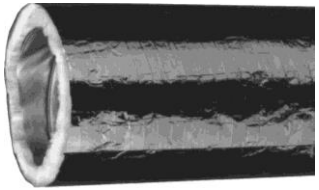
EL=10 ft.

EL=20 ft.

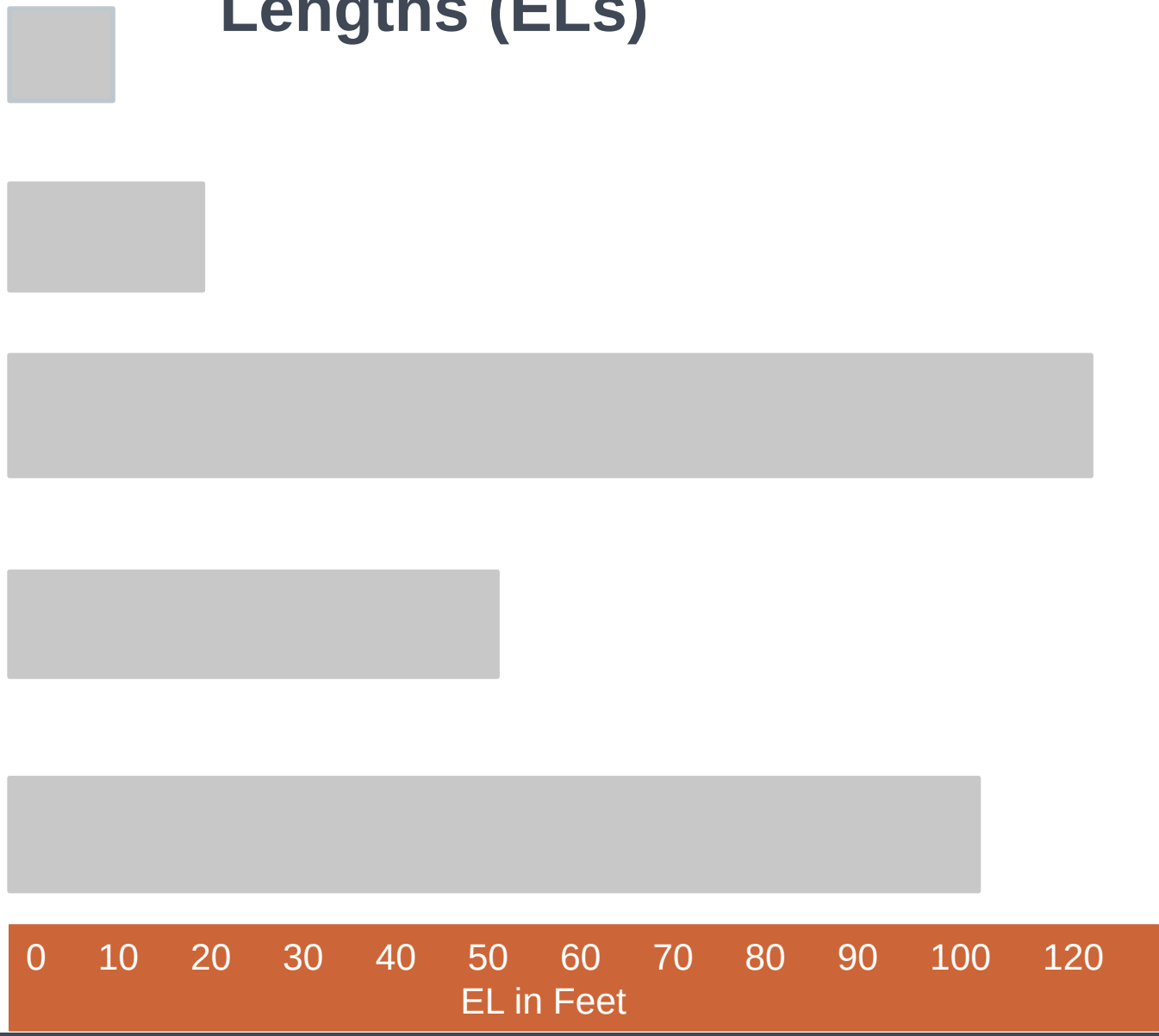


EL=120 ft.

50 ft. has an EL of 50 ft.

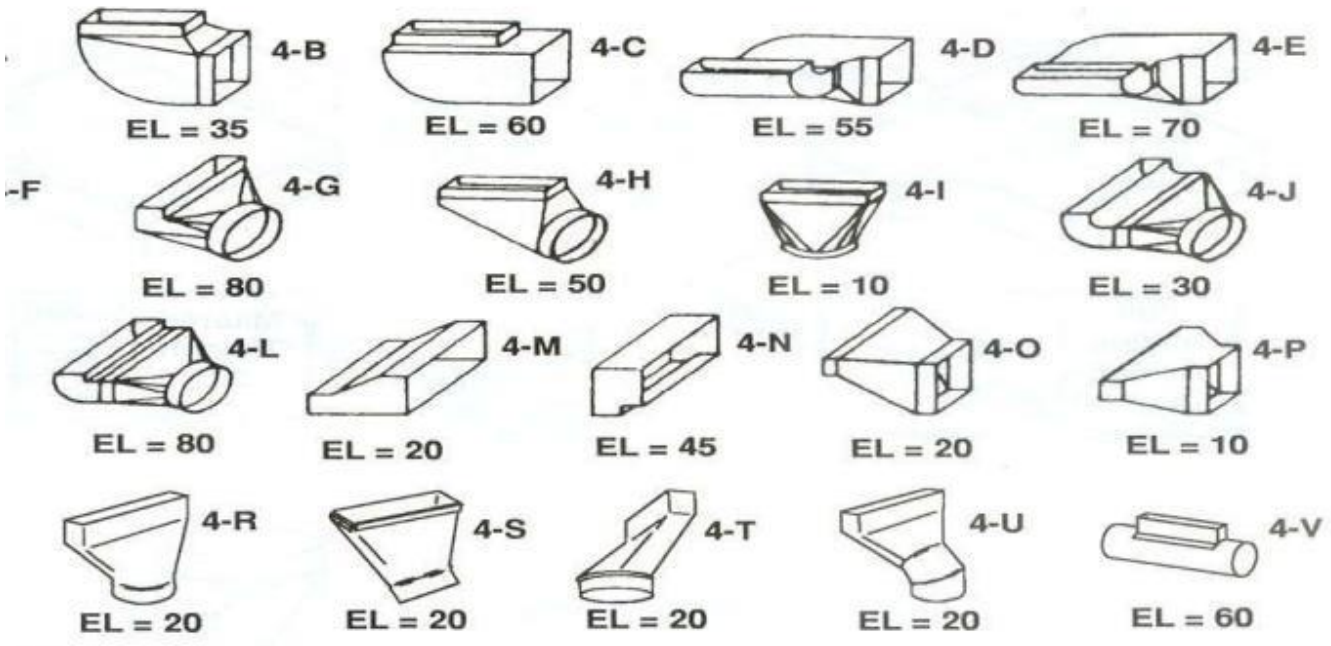


50 ft. of 15% compressed flex has an EL of 100 ft.



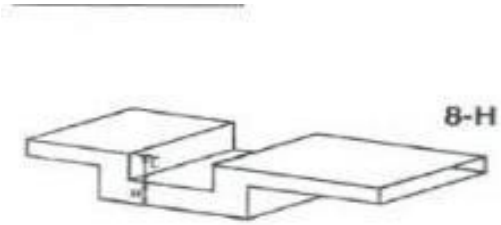
It’s the Fittings that Matter The Most

Group 4
Supply Air Boot and Stack Head Fittings
Reference Velocity = 900 FPM
Reference Friction Rate = 0.08 In.Wg. per 100 Feet

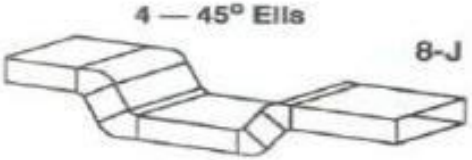


Most of the friction loss occurs at elbows, Ys, and other fittings.

Equivalent Length (EL)



EL's H/L	No Vanes	With Vanes
0.5	55	—
1.0	330	55
1.5	430	55
2.0	470	55



EL = 20

- ACCA's Manual D assigns an EL to every type of fitting used in a duct system.
- If a fitting has an EL of 35, it has the same resistance as 35 feet of straight pipe.

From EL to Total Equivalent Length T.E.L.

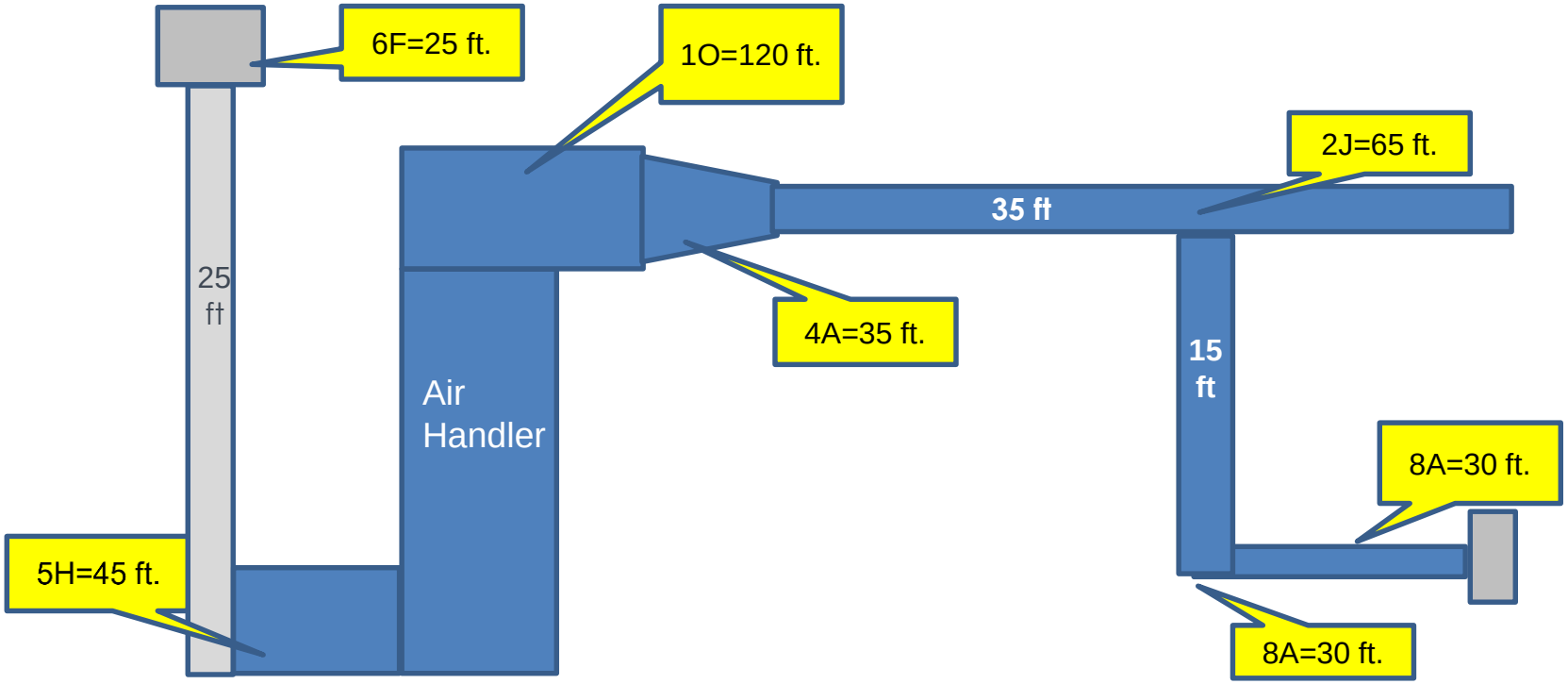
Total Equivalent Length (T.E.L.) is:

- the sum of all the individual ELs of the fittings and the length of the ducts along the air's longest path from the return grille through the supply grille.
- As a rule, you need to keep your T.E.L below 300.

It is not:

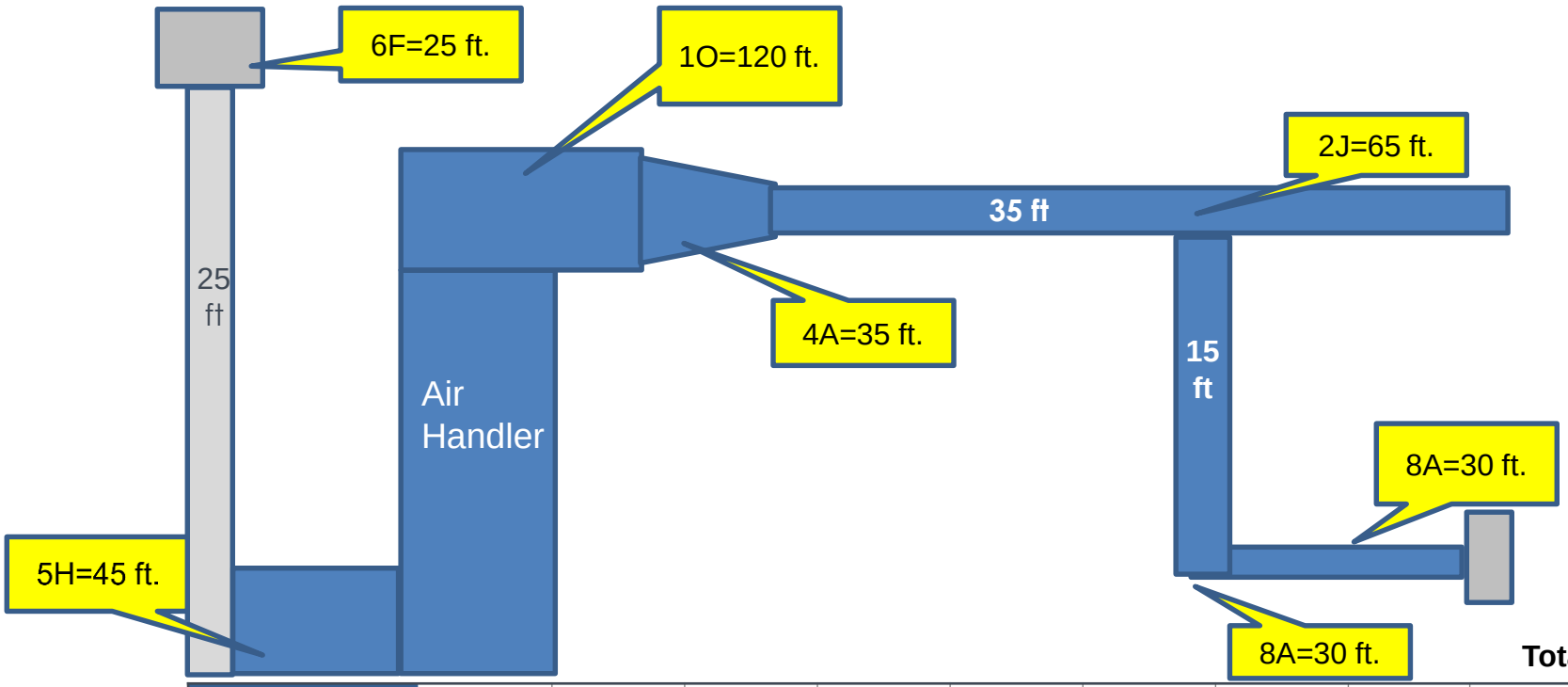
- The sum of ALL the fittings in the duct system.
- Not necessarily the longest path in terms of distance, but the longest path in terms of restriction.

Activity

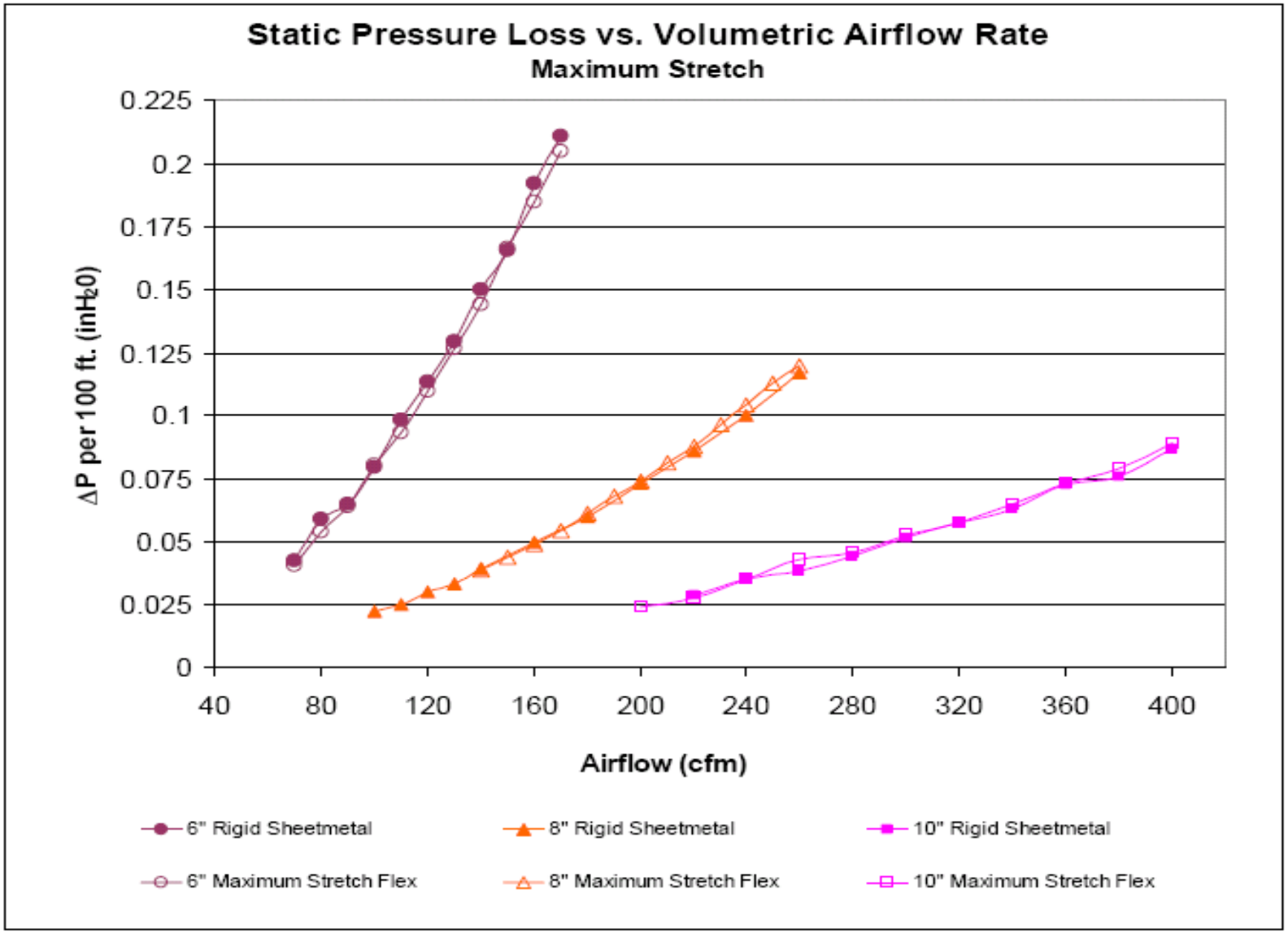


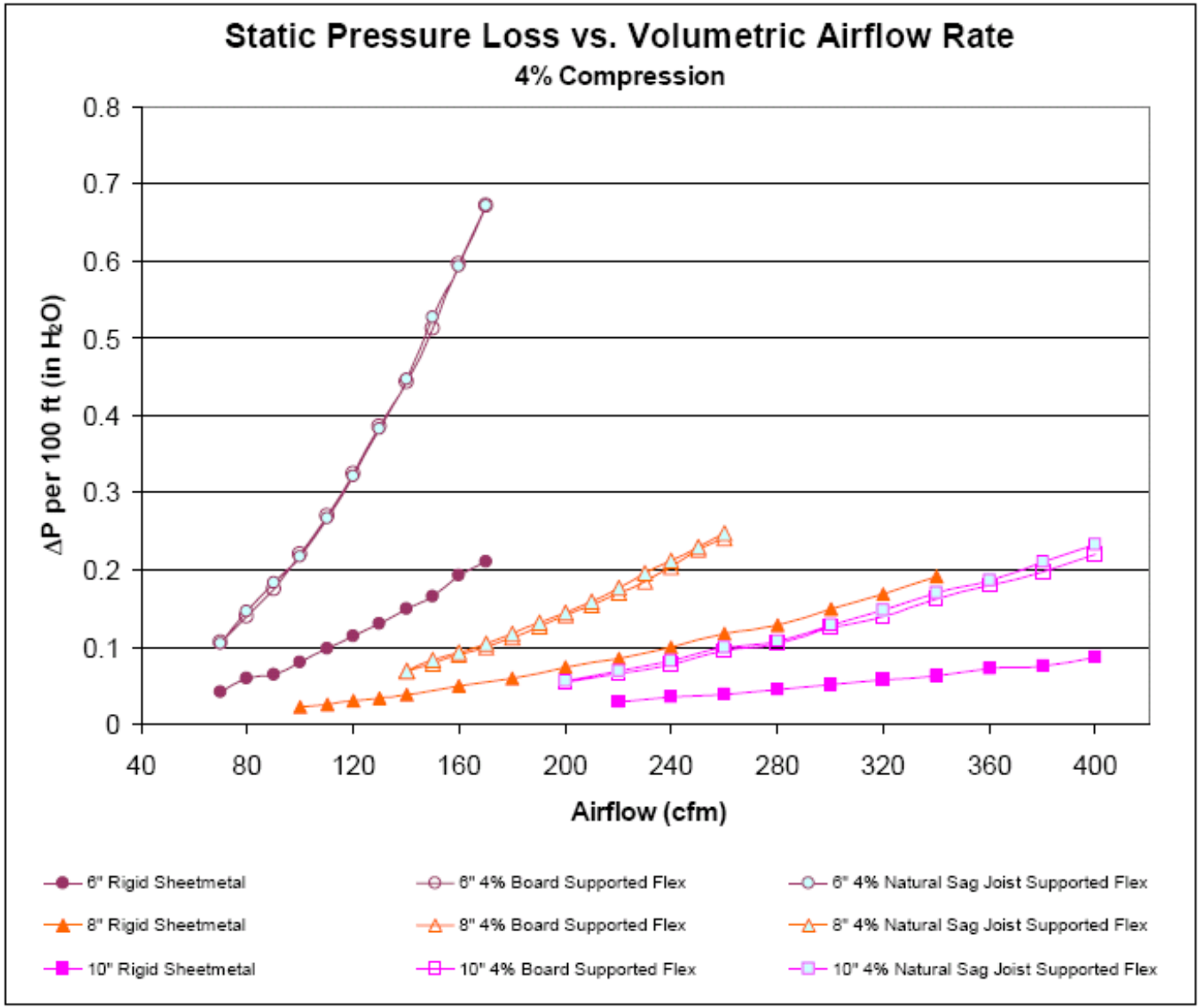
									Total
Duct Length	25	35	15	10	--	--	--	--	85
Fitting	6F	6N	5H	1O	4A	2J	8A	8A	--
EL	25	10	45	120	35	65	30	30	360
								Grand Total	445

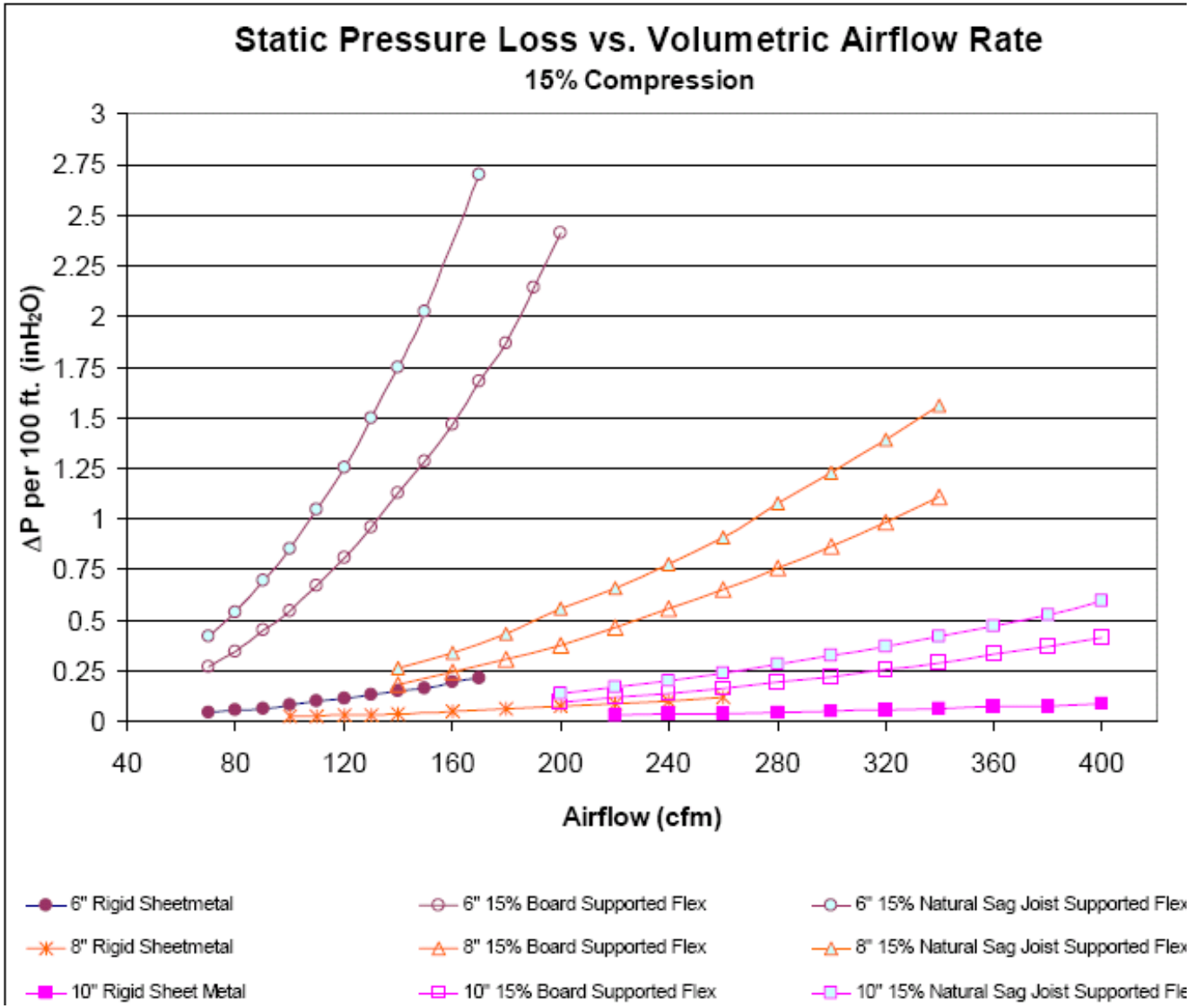
Activity



										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	8F	6N	5K	1I	4A	2J	8A	8A	--
	EL	15	10	10	20	35	65	30	30	215
									Grand Total	300


Static Pressure Loss vs. Volumetric Airflow Rate
Maximum Stretch
ΔP per 100 ft. (inH20)
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
40
80
120
160
200
240
280
320
360
400
Airflow (cfm)
6" Rigid Sheetmetal
8" Rigid Sheetmetal
10" Rigid Sheetmetal
6" Maximum Stretch Flex
8" Maximum Stretch Flex
10" Maximum Stretch Flex


Static Pressure Loss vs. Volumetric Airflow Rate
4% Compression
ΔP per 100 ft (in H2O)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
40
80
120
160
200
240
280
320
360
400
Airflow (cfm)
6" Rigid Sheetmetal
6" 4% Board Supported Flex
6" 4% Natural Sag Joist Supported Flex
8" Rigid Sheetmetal
8" 4% Board Supported Flex
8" 4% Natural Sag Joist Supported Flex
10" Rigid Sheetmetal
10" 4% Board Supported Flex
10" 4% Natural Sag Joist Supported Flex


Static Pressure Loss vs. Volumetric Airflow Rate
15% Compression
ΔP per 100 ft. (inH2O)
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
40
80
120
160
200
240
280
320
360
400
Airflow (cfm)
6" Rigid Sheetmetal
6" 15% Board Supported Flex
6" 15% Natural Sag Joist Supported Flex
8" Rigid Sheetmetal
8" 15% Board Supported Flex
8" 15% Natural Sag Joist Supported Flex
10" Rigid Sheet Metal
10" 15% Board Supported Flex
10" 15% Natural Sag Joist Supported Fle


Many Causes of Low Airflow


Courtesy of Advanced Energy

Courtesy of Advanced Energy


Courtesy of Advanced Energy

Courtesy of Advanced Energy


Courtesy of Advanced Energy

Courtesy of Advanced Energy


The Kinked Hose Syndrome

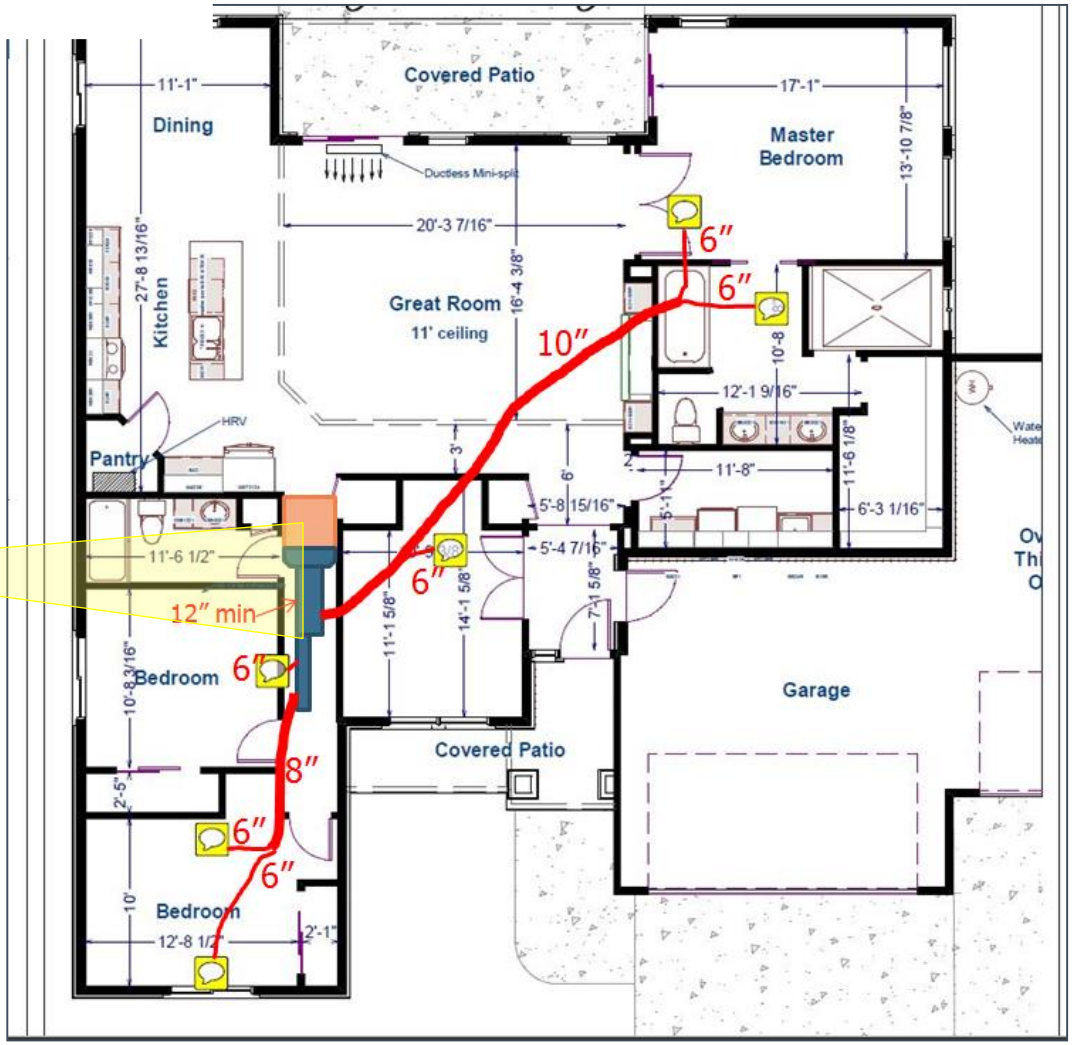
Why Do We Hang Ducts in Attics?

Duct Design Rules

1. Don’t do stupid stuff
2. Pick a unit that can deliver required CFM at expected pressure
3. No 90 degree turns
4. Stretch the flex
5. Don’t squish the flex
6. Use large return grilles and return ducts
7. MEASURE AIR FLOW
8. If you are counting: keep TEL below 300 feet
9. If using a Ductulator, use a .06 or .08 friction rate for design purposes.

The School of Hard Knocks

- A 18K DHP was installed first
- Then, we added a 9K mini-ducted variable refrigerant heat pump.
- What could go wrong?



DHP System Design

- Use an appropriate number of indoor heads
  - In most homes, one head per floor is enough

- An optimal system often consists of:
  - 1 DHP in the main living area, +1 smaller unit in the master suite
  - 1 DHP in the main living area, +1 ducted mini-split serving bedrooms
  - 1 DHP in the main living area, plus small electric resistance heaters in the bedrooms
  - If using ER heaters, use smaller units (750w), control with digital wall T-stats

DHP System Design

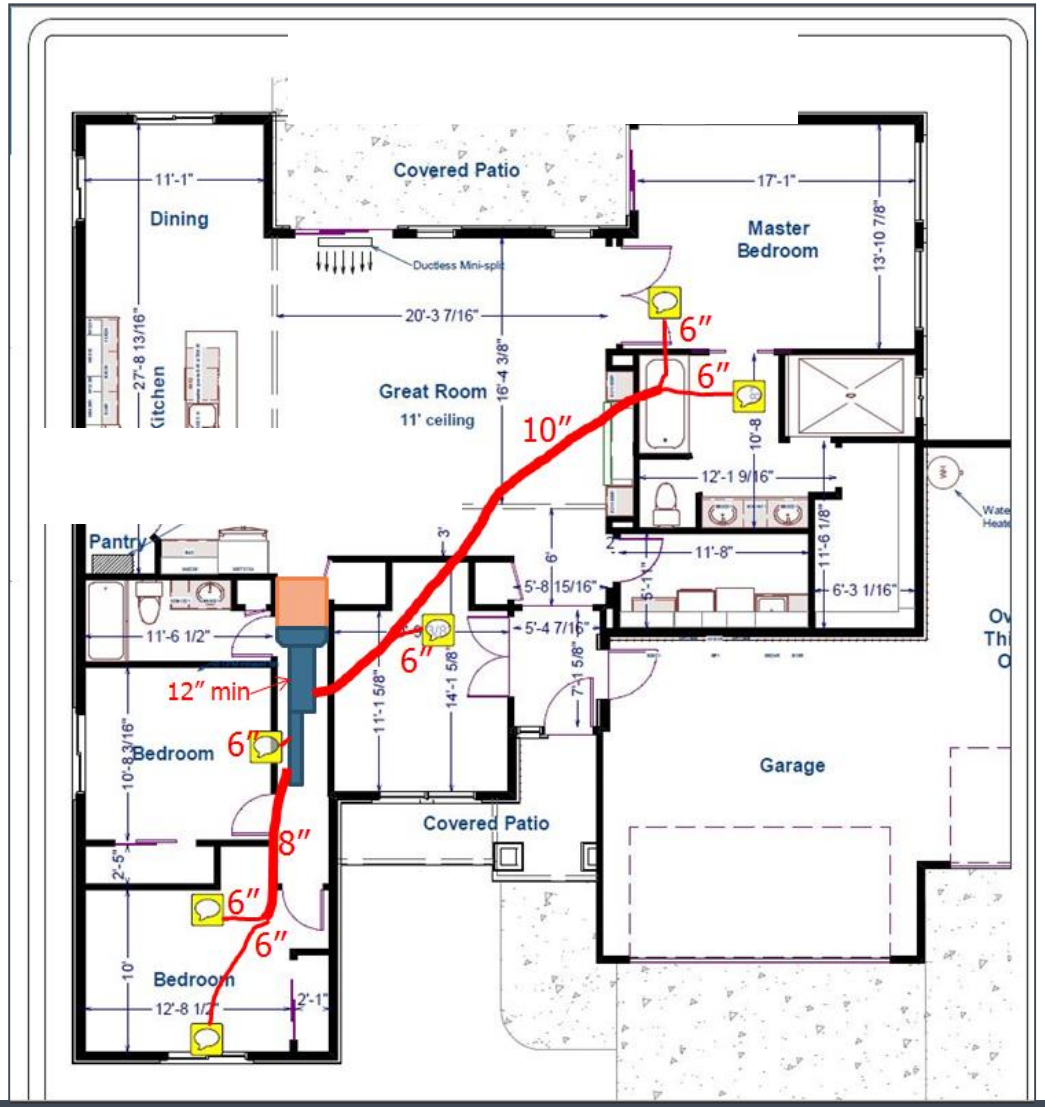
- Orient heads to take advantage of throw and mixing
  - Place in largest, most open areas
  - Orient to blow down central hallways
- In rooms with high ceilings, place DHP ≤ 8’ off the floor to minimize stratification effects
- Don’t set units set in “Auto” mode, leave in heating or cooling
- Set fan speed to auto fan, if lower capacity and efficiency will drop.

Avoid Control System Mistakes

Thermostats/Controllers: Not What You're Comfortable With

The School of Hard Knocks

- Perfect airflow flow in each room
- What could go wrong?

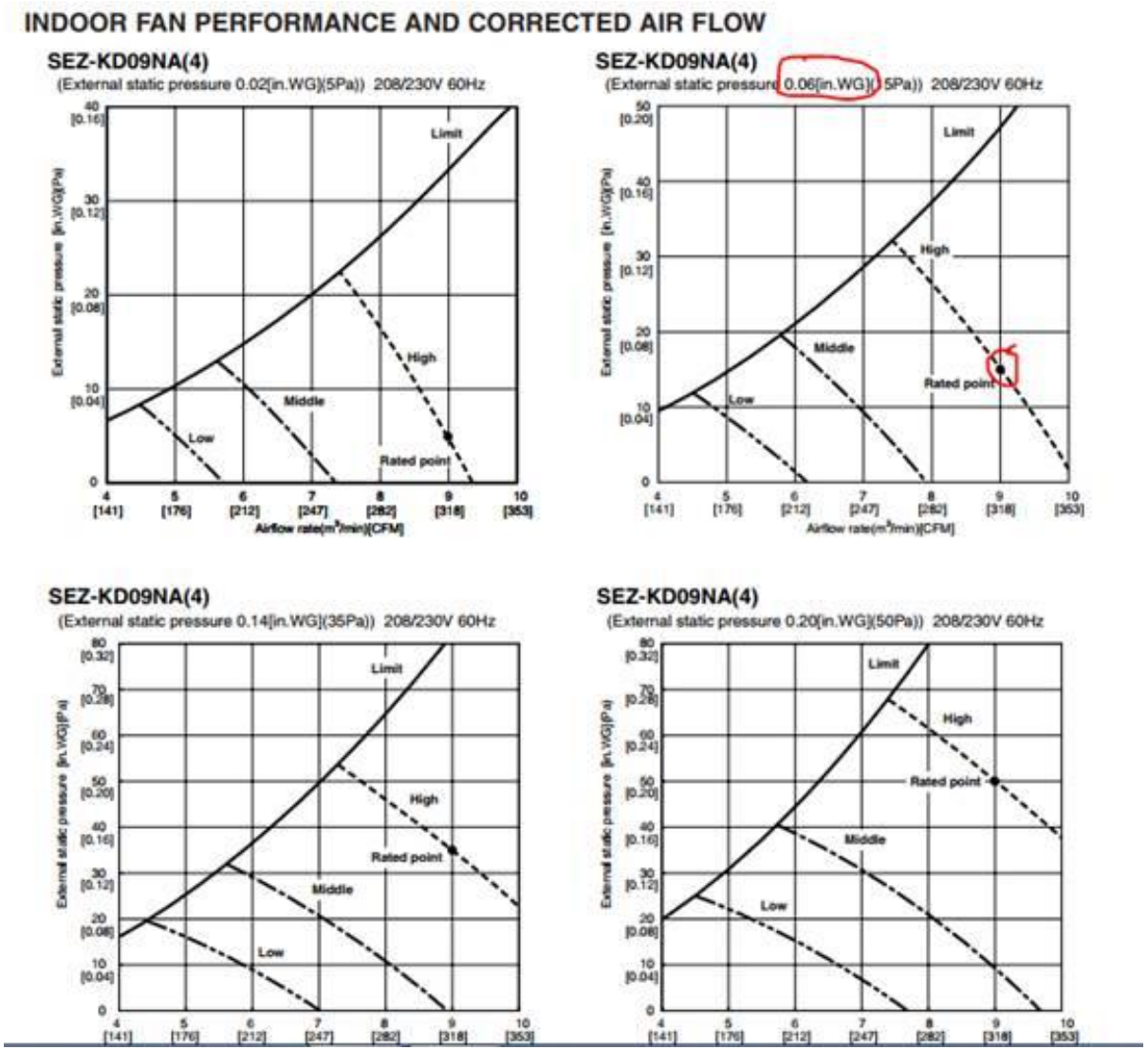


FUNCTION 42 and Other Settings

Setting the unit to sense temperature at the T-stat:

- Function 42 has to be set to “01” **and** the t-stat icon has to appear on the screen
- High Insulation setting needs to be activated

Where Fans and Controls Collide



Controller pitfalls explained

1. If using a wall-mounted controller, make sure it senses temperature at controller and not at air handler

2. If there is an option for efficient home, ensure it is selected. Set to High Insulation

3. Always set to high insulation setting

4. Read the manual

Commissioning

1. Put system in high heat or high cool mode if available
2. Measure external static pressure
3. Measure delivery at each register (if you have a flow hood)
4. Measure temperature gains
5. Conduct a duct leakage test if applicable
6. Check refrigerant charge against published values.

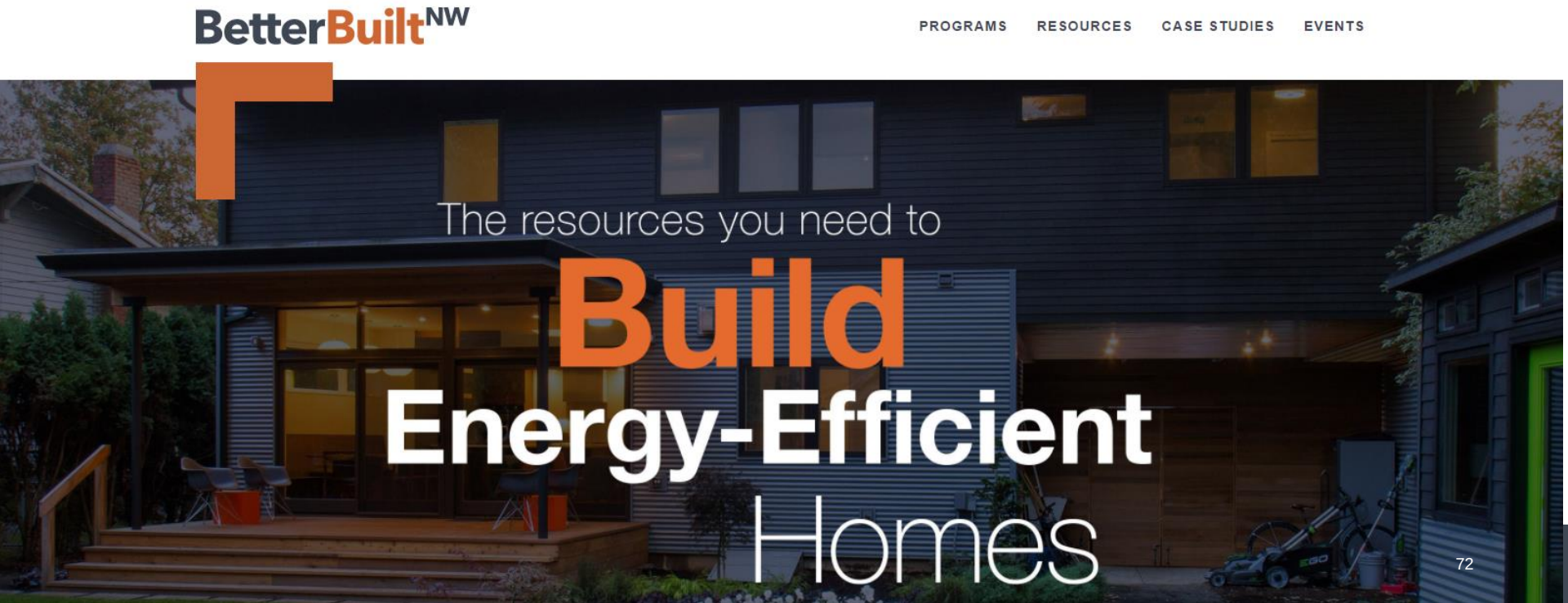
Summary

Why would a controller sensing temperature at the air handler affect efficiency?

How can you check where the temperature sensor is on most controller models?

Resources

- Better Built NW
- Local Home Energy Rater
- DOE's Building America Solutions Center
- Bruce Manclark



Goal Setting

What can you do in the next 24 hours?

Thank You

Bruce Manclark

info@betterbuiltnw.com