

HEAT PUMPS

DESIGNING HEAT PUMP INSTALLATIONS FOR HEATING AND COOLING

PART 1



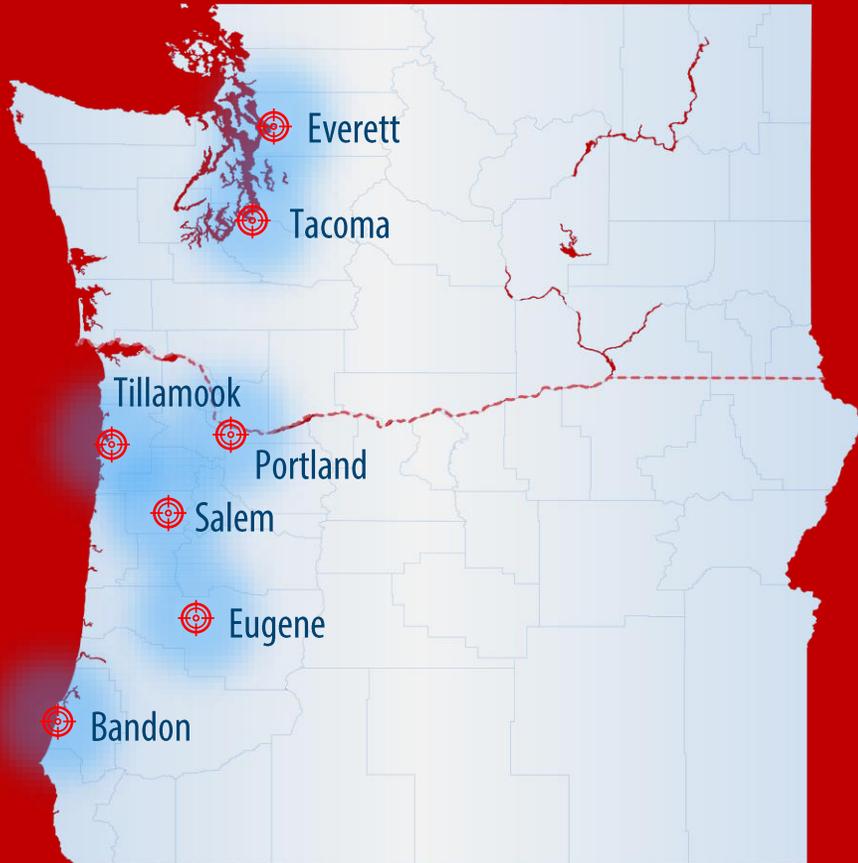
ABOUT

- **2005:** Began selling heat pumps in homes
- **2009:** Sales manager for a heat pump manufacturer
- **2011:** Owner of USA's largest "Ductless Heat Pump Only" contracting company
- **Now:** Heat pump business consultant

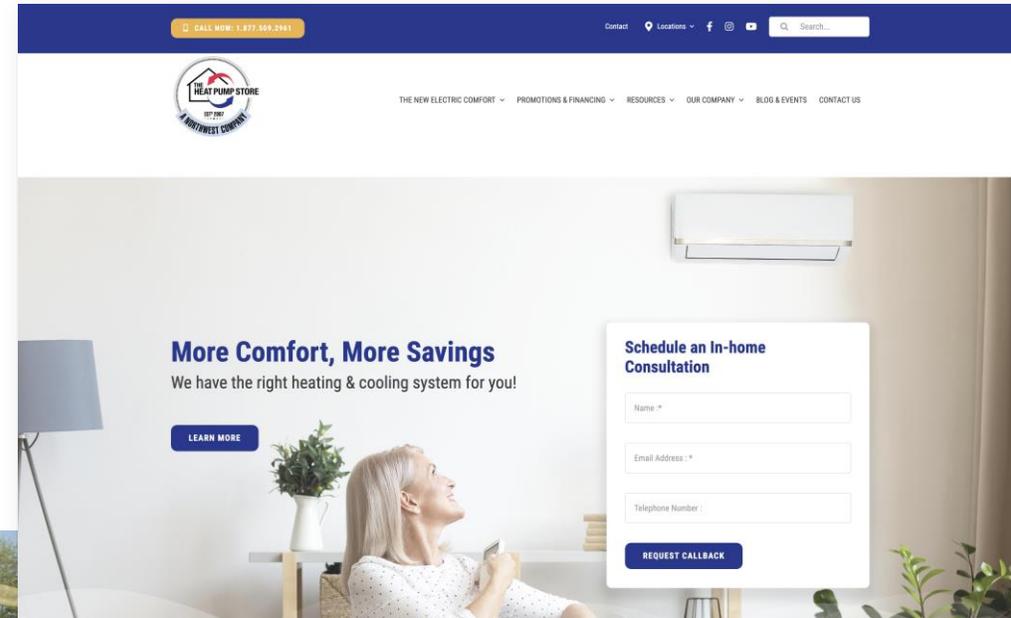
**JONATHAN
MOSCATELLO**



LOTS & LOTS OF HEAT PUMPS!



Jonathan's Contracting
Business Locations & Service
Area

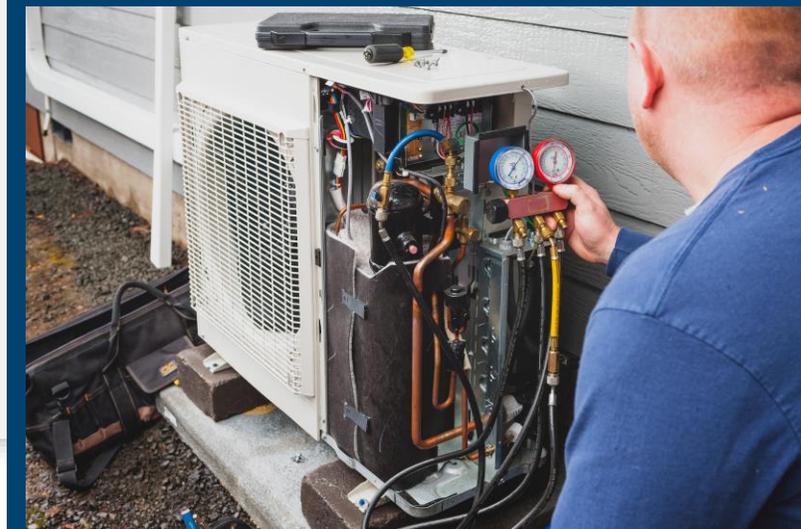


Special thanks for the support from



IN THIS SEMINAR...

Learn how to design heat pump installations that save energy and make homeowners more comfortable.



INTRODUCTION

DESIGNING HEAT PUMP INSTALLATIONS

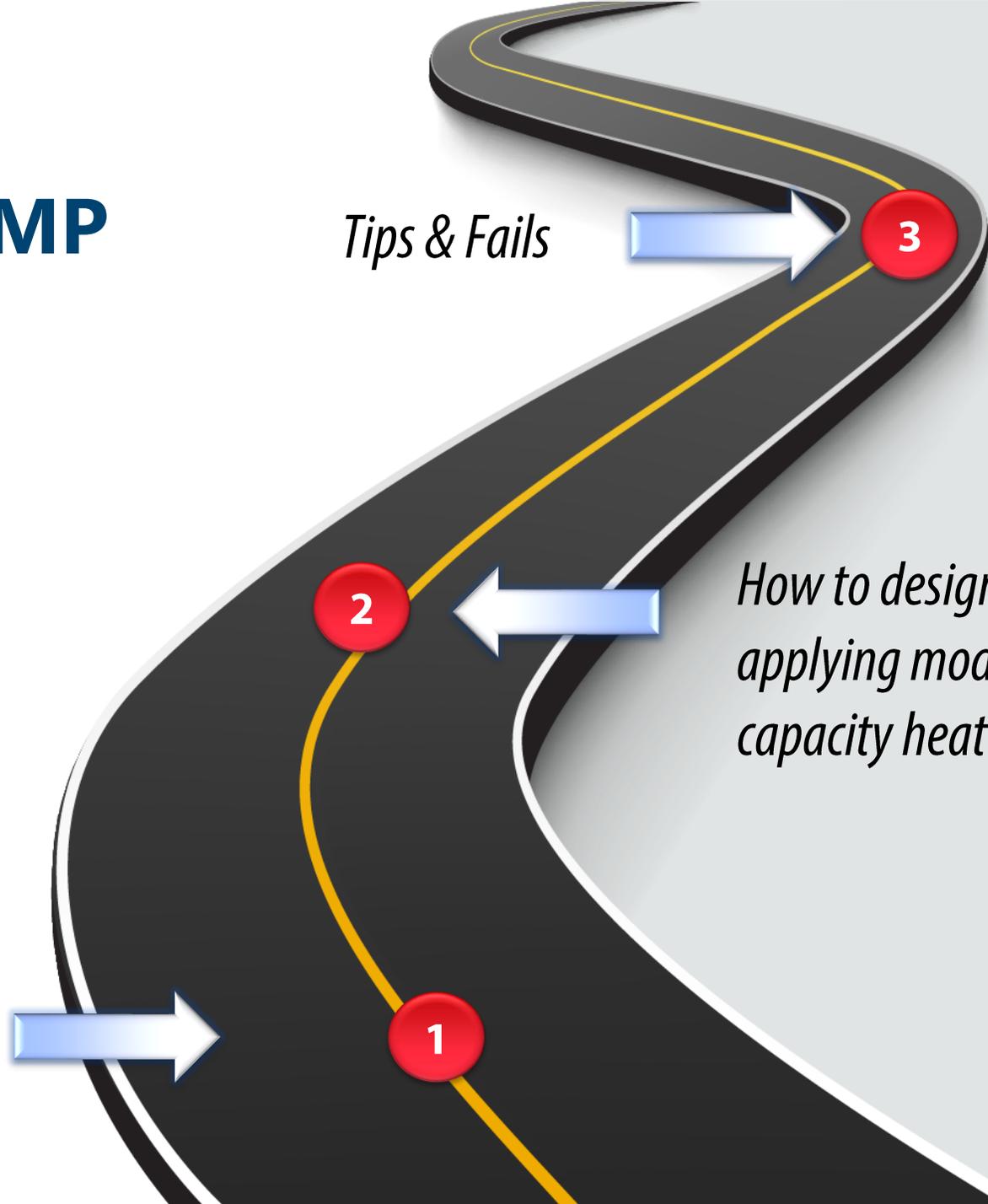
For Heating & Cooling

This helps you deliver on the claim that modern heat pumps deliver affordable comfort!

How heating & cooling installations are designed today

Tips & Fails

How to design when applying modern variable capacity heat pumps



FOR MOST CONTRACTORS

Residential heating design relies on use of:

Fossil Fueled Furnace

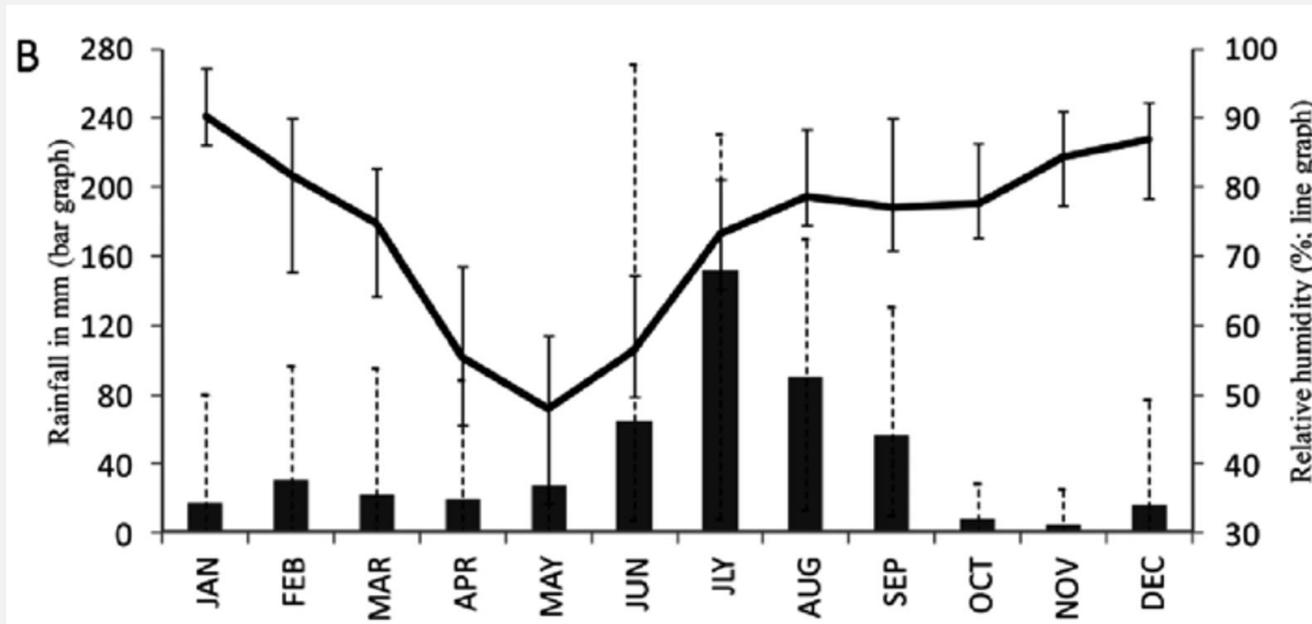


Air Conditioner



EQUIPMENT SELECTION

Is designed to cover the coldest day of the year, with a limited amount of excess capacity.



Excess furnace capacity allows for recovery from thermostat setback at nighttime or unoccupied hours.



The added cost for (reasonable) excess capacity is negligible



Model with **smallest** capacity

next highest capacity

next highest capacity

highest capacity

Customers and contractors alike agree that the benefits of excess capacity outweigh any additional cost.

VARIABLE CAPACITY HEAT PUMPS (VCHP):

A Different Design Strategy

We don't need or want to design for "Excess Capacity" when applying a VCHP.

There are two main reasons why:

- 1. NO SET-BACKS:** Nighttime or unoccupied setback use more energy. So "set it, and forget it"
- 2. WASTEFUL:** Designing for excess capacity wastes a lot of money!



THE FOUR STEP HEAT PUMP

Design Process

Always use when applying variable capacity heat pumps:

1 Perform a Load Calculation

2 Evaluate the Ductwork Capacity

3 Identify Low-Cost Building Envelope Improvements

4 Select the Heat Pump System



4-STEP H/P DESIGN PROCESS



STEP 1 *PERFORM A LOAD CALCULATION*

Don't design by guesswork...be a Pro!

Always perform a load calculation:

- You can't rely on current equipment sizes
- Many homes have had some upgrades over the years

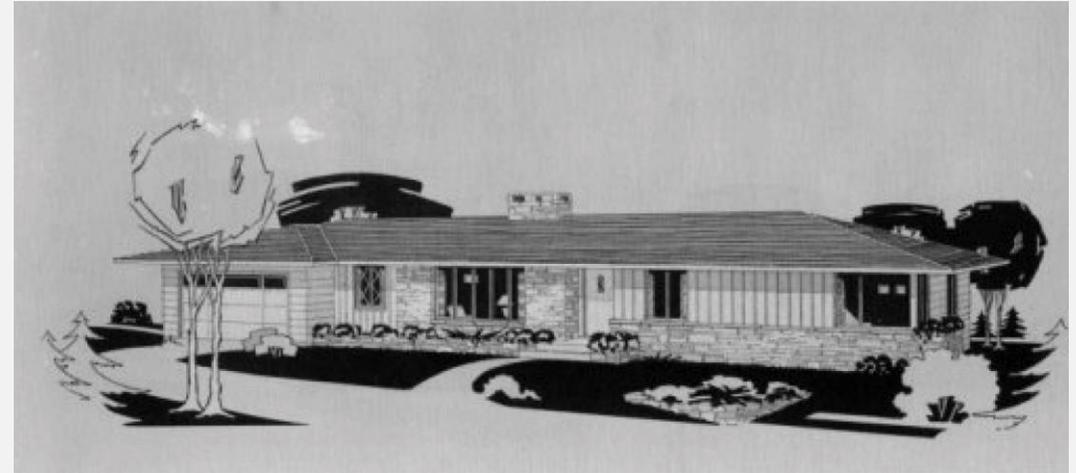


EXAMPLE

Load Calculation



- 1976 construction
- Conditioned area 2,020 ft²
- R-30 insulation in attic
- R-11 in walls
- 2 pane vinyl replacement windows
- Some air sealing
- Ducts in unfinished basement
- 8 ft ceilings
- South facing



Master Bathroom – 40ft²

Master Bedroom – 216ft²

Bedroom 1 – 216ft²

Bedroom 2 – 144ft²

Bedroom 3 – 180ft²

Family Room – 288ft²

Dining Room – 120ft²

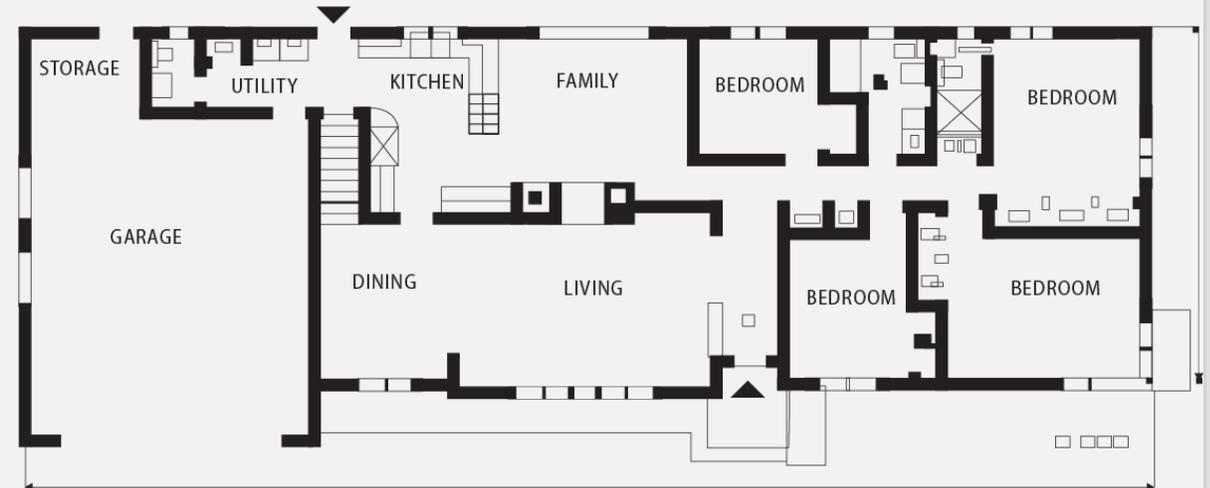
Living Room – 240ft²

Kitchen – 216ft²

Utility – 70ft²

Hallway – 170ft²

Bathroom 1 – 120ft²



SITE INFO

All weather data assumes sizing using the 1% hourly average.



HVAC SIZING TOOL

Duluth Ranch Home
Site ID: 8578 Heating: 51,900 BTU/hr
Area: 2,020 ft² Cooling: 13,800 BTU/hr
Climate: Duluth AP Latent: 2,500 BTU/hr

HELLO JONATHAN MOSCATELLO NEW SITE SITES REPORTS CONFIGURE HELP ACCOUNT

SITE BUILDING ROOMS WINDOWS OVERRIDES OPTIONS SYSTEM DUCT DESIGN DUCT RESULTS RESULTS SUBMIT

Site ? ← Click the question mark on all of the site information pages to get general help on that page. Save

✓ Duluth Ranch Home loaded.

Project Name

Address 1

Address 2

State/Province

Weather Location ⌵

Zip/Postal Code

Subdivision

Lot Number

Plan/Model Number

Builder

Utilities

(only utilities present in your zip code are shown)

Save Cancel changes Print

BUILDING INFO

Pre-set construction values for insulation, windows and more. These can be refined later.



Building

Save

Conditioned Floor Area Floors Above Grade
Average Wall Height Bedrooms

Note: **Default insulation level** below is meant to provide a starting point for the house you are evaluating. You are able to override any specific items on later pages to override these default values. Please take care to override where necessary.

Default Insulation Level Show all
Foundation Type
Duct Location
Direction Front Door (House Orientation)
Year Built

Uploaded Drawing Files

There are no files currently associated with this site.

Upload Drawing Files

Upload any drawing files you would like to attach to this site (pdf, jpg, png formats only. Max 5 files. 8 MB per file)

Save

Cancel changes

Print

Rooms ?

Save

✔ Building sq ft correctly matches floor area.

Building Sqft: 2,020

New Room	Room Name	Floor Area	Exterior Length	Height Override	Unconditioned Above Ceiling	Unconditioned Below Floor	In Basement	Redistribute Room
Delete	Master Bathroom	40	5.0		100%	0%	<input type="checkbox"/>	
Delete	Master Bedroom	216	30.0		100%	0%	<input type="checkbox"/>	
Delete	Bedroom 1	216	30.0		100%	0%	<input type="checkbox"/>	
Delete	Bedroom 2	144	12.0		100%	0%	<input type="checkbox"/>	
Delete	Bedroom 3	180	12.0		0%	100%	<input type="checkbox"/>	
Delete	Family Room	288	16.0		0%	100%	<input type="checkbox"/>	
Delete	Dining Room	120	10.0		100%	0%	<input type="checkbox"/>	
Delete	Living Room	240	20.0		100%	0%	<input type="checkbox"/>	
Delete	Kitchen	216	12.0		100%	0%	<input type="checkbox"/>	
Delete	Utility	70	14.0		0%	100%	<input type="checkbox"/>	
Delete	Hallway	170	5.0		0%	100%	<input type="checkbox"/>	
Delete	Bathroom 1	120	8.0		100%	100%	<input type="checkbox"/>	
		Total = 2,020						

Save

Cancel changes

Print

ROOM INFORMATION

ROOM INFORMATION is entered in a simple table.



WINDOW AND DOOR INFORMATION

Windows and doors entered in the correct orientation and in the room in which they are located.



HVAC

SIZING TOOL

Duluth Ranch Home

Site ID: **8578** Heating: **51,900** BTU/hr
 Area: **2,020** ft² Cooling: **13,800** BTU/hr
 Climate: **Duluth AP** Latent: **2,500** BTU/hr

HELLO JONATHAN MOSCATELLO |
 NEW SITE |
 SITES |
 REPORTS |
 CONFIGURE |
 HELP |
 ACCOUNT

SITE
BUILDING
ROOMS
WINDOWS
OVERRIDES
OPTIONS
SYSTEM
DUCT DESIGN
DUCT RESULTS
RESULTS
SUBMIT

Windows ?

✔ Window to floor ratio: 15%

Window U-Value Window SHGC

Room Name	↑ N	↗ NE	→ E	↘ SE	↓ S	↙ SW	← W	↖ NW	Door	Skylight
Master Bathroom	3.0									
Master Bedroom	15.0		15.0							
Bedroom 1			25.0		25.0					
Bedroom 2					15.0					
Bedroom 3	15.0									
Family Room	40.0									
Dining Room					15.0					
Living Room	40.0									
Kitchen	15.0								21.0	
Utility	8.0								21.0	
Hallway									21.0	
Bathroom 1	8.0									

Rotate house orientation

Save
Cancel changes
Print

OPTIONS AND OVERRIDES

Dial in site specific factors such as insulation, weather, infiltration, occupants, internal loads, etc. using overrides and options



HVAC SIZING TOOL

HELLO JONATHAN MOSCATELLO

NEW SITE SITES REPORTS CONFIGURE HELP ACCOUNT

Duluth Ranch Home
Site ID: 8578 Heating: 52,200 BTU/hr
Area: 2,020 ft² Cooling: 13,800 BTU/hr
Climate: Duluth AP Latent: 2,500 BTU/hr

SITE BUILDING ROOMS WINDOWS **OVERRIDES** OPTIONS SYSTEM DUCT DESIGN DUCT RESULTS RESULTS SUBMIT

Overrides ⓘ Save

✓ Values successfully saved.

	Default	Rough Equiv Override	Value
Ceiling U-Value	0.049	(R-19) R-30	0.032
Floor U-Value	0.047	(R-20) Frame Floor, R-19	0.049
Wall U-Value	0.097	(R-10) Default	
Basement Wall U-Value	0.093	R-0	0.125
Basement Floor U-Value	0.025	Default	
Slab F-Value	1.180	Default	
Door U-Value	0.500		
Window U-Value	0.400		
Window SHGC	0.580		
Duct Insulation	R-4	Default	
Duct Leakage	Average	Default	
Winter Infiltration ACH	0.500		
Summer Infiltration ACH	0.250		

Save Cancel changes Print

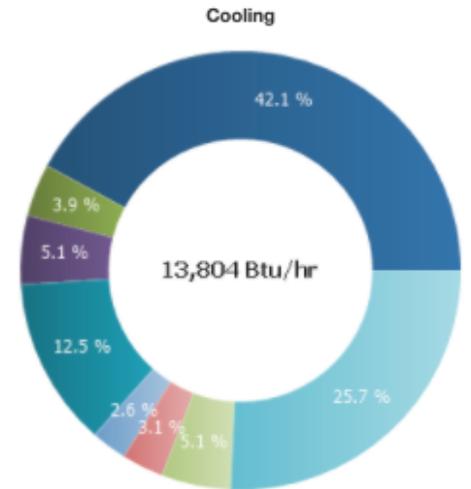
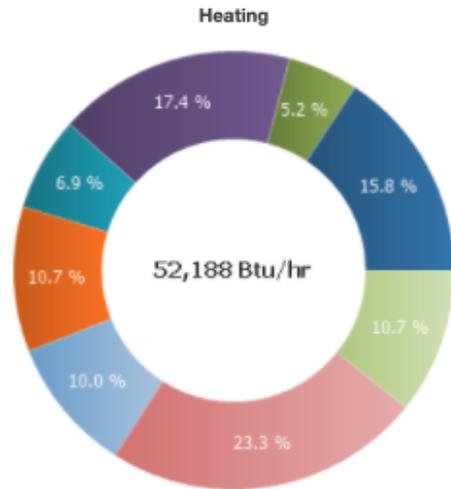
result of heating LOAD CALCULATION

Room Data and Loads hide from printout

Room Name	Suggested Ducts	Actual Ducts	Duct Size	CFM/Duct	Actual CFM Measured	Floor Area	Ext. Length	Height Override	Uncond Ceiling	Uncond Floor	Heating Load	Cooling Load
Master Bathroom	1		4	36		40	5.0		100 %	0 %	1,093	215
Master Bedroom	3		4	95		216	30.0		100 %	0 %	6,773	2,070
Bedroom 1	4		4	123		216	30.0		100 %	0 %	7,365	3,257
Bedroom 2	2		4	67		144	12.0		100 %	0 %	3,127	1,055
Bedroom 3	2		4	67		180	12.0		0 %	100 %	4,152	649
Family Room	2		4	100		288	16.0		0 %	100 %	6,252	1,230
Dining Room	2		4	63		120	10.0		100 %	0 %	2,680	958
Living Room	2		4	92		240	20.0		100 %	0 %	5,655	1,508
Kitchen	2		4	69		216	12.0		100 %	0 %	4,364	1,202
Utility	2		4	88		70	14.0		0 %	100 %	5,028	536
Hallway	1		4	79		170	5.0		0 %	100 %	2,617	548
Bathroom 1	1		4	101		120	8.0		100 %	100 %	3,084	575
Total	24	0				2,020					52,188	13,804

Component Loads hide from printout

	Heating	Cooling	Color
Windows	8,222	5,807	Blue
Skylights	0	0	Red
Doors	2,709	536	Green
Walls	9,093	698	Purple
Ceiling	3,611	1,721	Teal
Floors	5,581	0	Orange
Ventilation	5,212	364	Light Blue
Infiltration	12,166	424	Red
Ducts	5,595	704	Light Green
Additional Blower		0	Purple
Internal Gains		3,550	Light Blue
Total:	52,188	13,804	



with this data, we learn a few

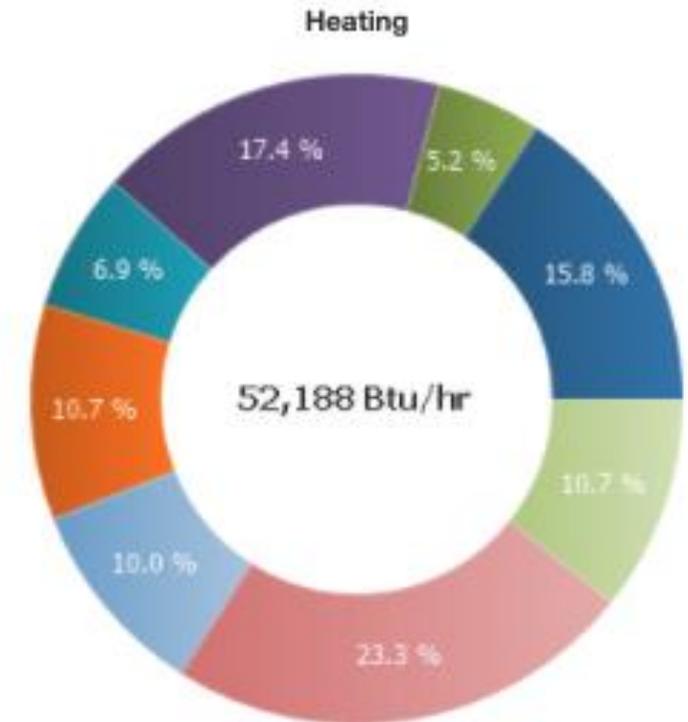
KEY THINGS:

- 1) Heating and cooling requirements are generally less than guessed
- 2) “Where” the heating loss occurs is helpful—it shows us where we can look for simple, low cost weatherization upgrades.



Component Loads hide from printout

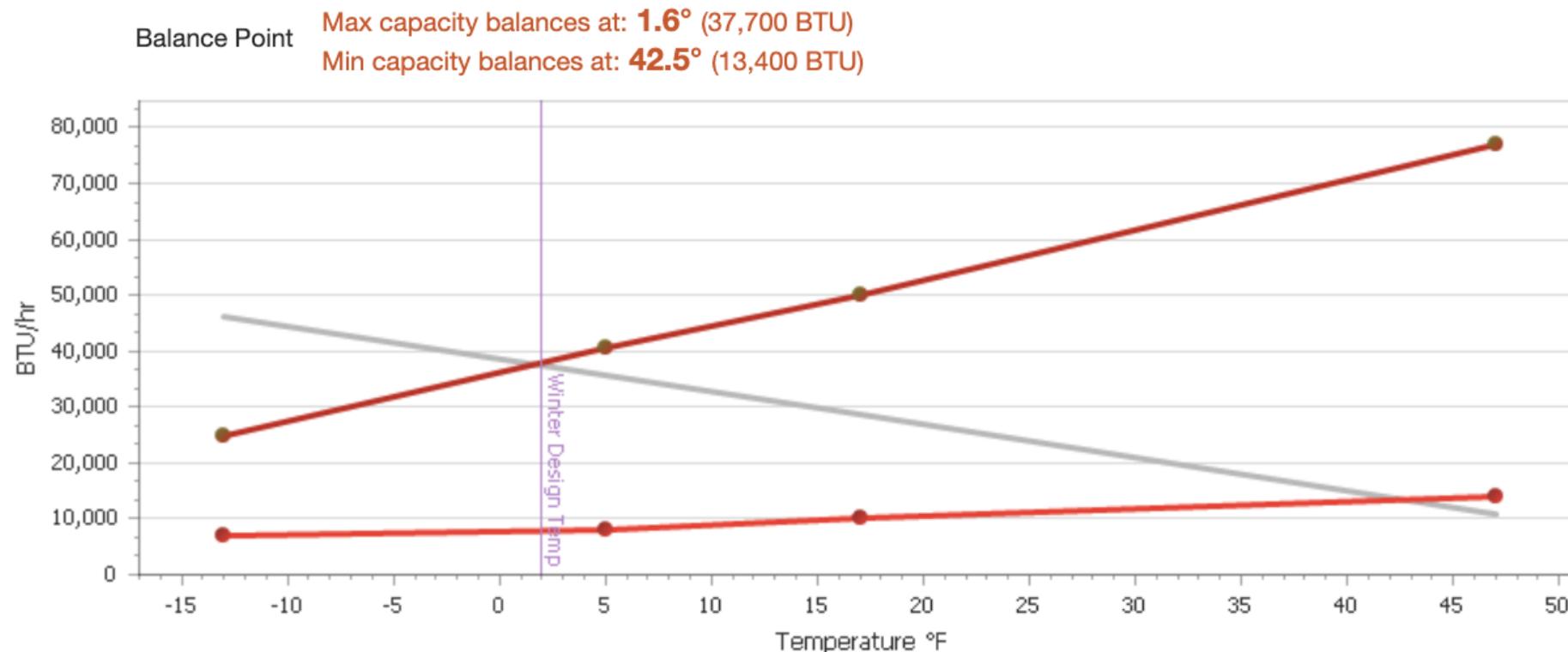
	Heating	Cooling	Color
Windows	8,222	5,807	Blue
Skylights	0	0	Red
Doors	2,709	536	Green
Walls	9,093	698	Purple
Ceiling	3,611	1,721	Teal
Floors	5,581	0	Orange
Ventilation	5,212	364	Light Blue
Infiltration	12,166	424	Pink
Ducts	5,595	704	Light Green
Additional Blower		0	Dark Purple
Internal Gains		3,550	Cyan
Total:	52,188	13,804	



result of EQUIPMENT SELECTION

One simple graph shows both the heating requirement and heat pump performance—this makes your job easier!

Required Heating

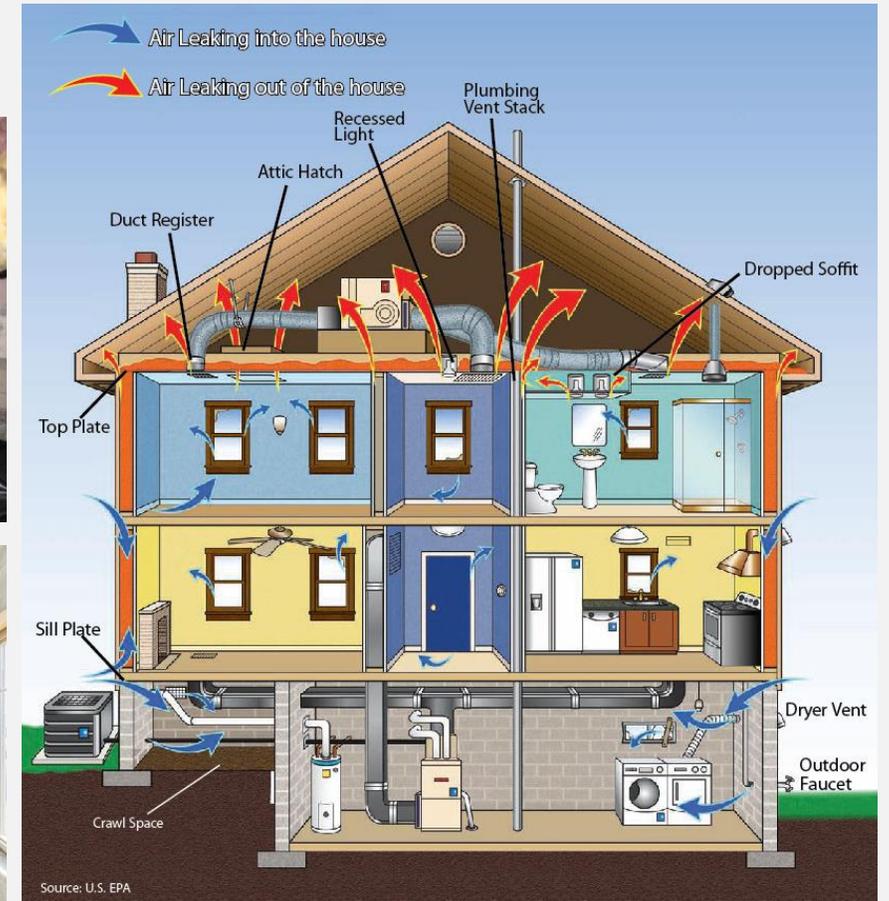


4-STEP H/P DESIGN PROCESS

STEP 2 *EVALUATE EXISTING DUCTWORK*

If your design reuses existing ductwork:

Can it handle the new system air requirement?



Use Ductulator & Worksheet

*Ensure ductwork can handle **MAXIMUM** system airflow*

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 CFM	Duct Height - Net inside dimension in inches											
	4"		6"		8"		10"		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			
				1300	32x8	1800	32x10	2300	32x12			
				1400	34x8	1930	34x10	2450	34x12			
				1500	36x8	2060	36x10	2600	36x12			
40	2 1/2 x 10					2200	38x10	2750	38x12			
70	2 1/2 x 14					2350	40x10	2900	40x12			
150	2 1/2 x 30							3050	42x12			
		100	3 1/2 x 14									
		220	3 1/2 x 30									

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

INSTRUCTIONS FOR USE

Step One - Identify the volume of air that will be passing through the duct

Step Two - Select the duct size from the table that can carry that volume of air

Step Three - If desired airflow exceeds the CFM rating, increase to the next duct size

Step Four - Listed CFM is based on typical field results and may vary. Install dampers

Step Five - If duct run exceeds 25', or has excessive transitions, increase to the next size

Step Six - Design alone is inadequate, always prove design by test and balance.

© 2005 NCI, Inc.

Anari
 cnc@anari.o.ou,
 email=anari2011
 @gmail.com, c#IR



EXAMPLE

EVALUATING EXISTING DUCTWORK

1 Calculate TRUNK maximum capacity

Width: _____ OR Round-pipe Diameter: _____

Height: _____

Use DUCTULATOR @ 0.1" ESP to calculate maximum airflow:

_____ CFM

2 Calculate total RUN capacity

Duct Diameter	Metal Pipe	Flex Duct	ENTER # of Runs	Multiply # x CFM / run
4"	40	40		
5"	50	50		
6"	85	75		
7"	125	110		
8"	180	160		
9"	240	225		
10"	325	300		
ADD all values from right hand column >				CFM

3 Which value is greater?

Enter TRUNK or total RUN capacity _____ cfm and Divide by 400 cfm/ton _____.

The resulting number is the maximum heat pump "tonnage" the ductwork can handle.



4-STEP H/P DESIGN PROCESS



STEP 3 *Evaluate the BUILDING ENVELOPE*

THE GOAL



**Lower the heating requirement,
making application of a VCHP easier**



Look for easy, low-cost improvements.

MASTERY: Partner with a weatherization contractor!

LOW-COST WEATHERIZATION IDEAS

To reduce *HEAT LOSS* through the *BUILDING ENVELOPE*

Look for easy, low-cost improvements, like these:

- Air seal and insulate the attic access
- More attic insulation
- Air seal and insulate ductwork
- Seal cracks and air gaps around foundations and fenestrations

GOAL: Try to REDUCE the heating load calculation by 6,000 or more!



4-STEP H/P DESIGN PROCESS



STEP 4 *Selecting the HEAT PUMP SYSTEM*

Your selection should be influenced by:

1. Load calculation
2. Ductwork capacity
3. Building envelope improvements

✓ *Let's review some **TIPS & FAILS** for heat pump selection!*



WHAT ABOUT THE **DESIGN DIFFERENCES**

*Between Standard AC and
Variable Capacity H/P?*



It depends on the type of H/P you are selecting:

- **VCHP:** Pick for the larger of the two loads.
- **Single speed:** Pick for the smaller of the two loads.



COMPARISON OF HOW TO SIZE EQUIPMENT



Heat Pump Type	Variable Capacity	Single Speed
Sizing method	Sized for heating load. Choose BTU output to MAX out ductwork capacity.	Sized for cooling load. Do not oversize.
Quantity of Back-up Heat	Small capacity heater used make up GAP between H/P output and heating design requirements.	Large capacity of heater used replace H/P capacity.
Operation of Back-up Heat	Very little usage, thanks to large heat pump capacity and good low-temp operation.	High usage because heat pump "balance point" is high.

TIPS

for equipment selection & installation design

1. Know your equipment options
2. Try using multiple heat pumps
3. Use secondary heating sources on the coldest days
4. Be prepared for “Empty Nester’s”
5. Learn the “Displacement technique”
6. The undersized ductwork solution



TIP #1

Know Your VCHP Equipment Options

There are several types of Variable Capacity Heat Pumps:

1. Cold-Climate VCHPs
2. Multi-zone VCHPs
3. Many **indoor unit** options to choose from



Your **CHOICE** in **TYPE** should depend on where you live and the design goals of the project!

TIP #2

Try Using Multiple Heat Pumps

There are times when its best to use multiple systems in the home...

- ✓ When one large system will use more energy than two small systems
- ✓ When you need lots of BTUs
- ✓ When there are "hot spots and cold spots" (bad ductwork)



COMPARING CAPACITY DIFFERENCES

Between Multi-Zone and Single Zone Heat Pumps

Total Capacity at TEMPS	Daikin 4MXS36 Multizone	Daikin 4MXL36 Cold-Climate Multizone	(2) Daikin RXL18 Single Zone
47° F	43,000	54,500	(2) X 28,000 = 56,000 TC
17° F	32,000	45,000	(2) X 25,000 = 50,000 TC
5° F	23,000	36,000	(2) X 21,000 = 42,000 TC
-13° F	- Not rated -	23,000	(2) X 15,000 = 30,000 TC



TIP #3

Design for use of secondary heat on the coldest days of the year

- The number of days with extreme temperatures are very few. Incorporate secondary heating sources to supplement the VCHP.
- This reduces the heating requirement significantly, making a VCHP application easier.

Secondary heating sources include:

Heated floors and towel tracks, fireplace inserts, wood stoves, electric baseboards, and more!

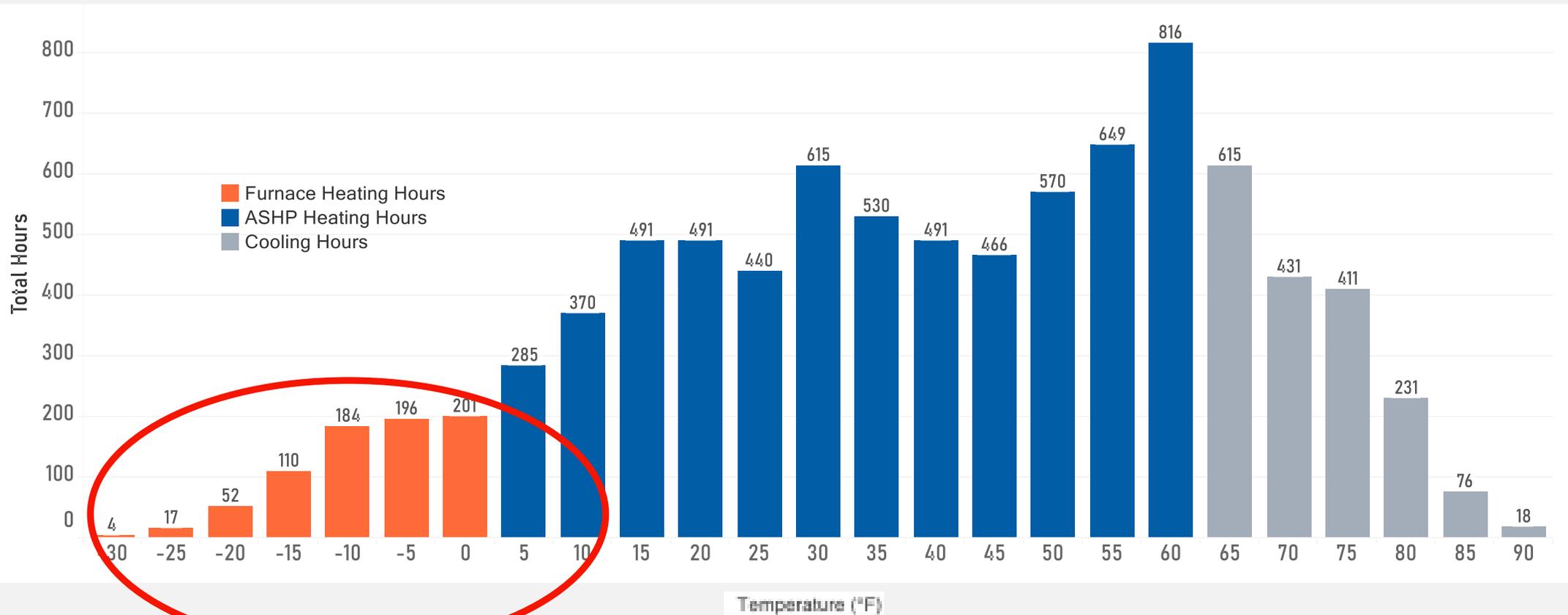


BIN WEATHER DATA



ST. CLOUD

Less than 5% of heating hours are below 5°F



TIP #4

Be Prepared for “Empty Nesters”

This is a big opportunity!

When the kids move out, why condition the whole home?

The central system is working, but we use a two-zone ductless system to condition:

1. The master bedroom
2. The kitchen/family room



 **HEAT
PUMP
NATION**

TIP #5

Learn & Use the “DISPLACEMENT” Technique

DISPLACEMENT

Allows people to try a heat pump without a huge investment to convert the entire home.



DISPLACEMENT SOLUTION: Single-head ductless system in primary living area; existing heat remain used as back-up.

TIP #6

Be Prepared for the **UNDERSIZED DUCTWORK** Scenario



This will sometimes occur, when in older homes that originally had oil or low-pressure natural gas furnaces.

1. Learn to evaluate the ductwork — ***can it handle the heat pump's system air?***
2. If needed — use a second indoor unit (ductless) to drop the additional conditioning needed to meet load requirements.

Second Indoor Unit to Contribute Additional Conditioning



Central System on Undersized Ductwork



Typical

FAILS

to watch out for and avoid!

1. Relying on Guesswork
2. Opening Pandora's Box
3. Applying One Big Heat Pump
4. Bigger is Better
5. Too Many Heads
6. The Undersized Ductwork Solution



FAIL #1

Relying on Guesswork

In particular, be sure to research and know the **Equipment Capacity.**

Research the manufacturer's engineering performance data to learn what the unit can produce at your design temperature.



FAIL #2

Opening Pandora's Box

With your installation "layout" or design,
keep it simple.

Lots of installers get overly complicated
(primarily a ductless issue):

1. System layout too complicated
2. Too many indoor units
3. Poor choice of indoor unit

"Just because you **CAN** do something, doesn't mean you **SHOULD**"



FAIL #3

Applying **ONE** **BIG** Heat Pump

Eliminate “Central Plant” style thinking.

With VCHP’s in some cases two outdoor units will be needed:

1. In homes with very large heating loads
2. Homes with ductworks issues (Hot Spots/Cold Spots)
3. [With Ductless] it can reduce labor and materials costs

“Sometimes two is better than one”



FAIL #4

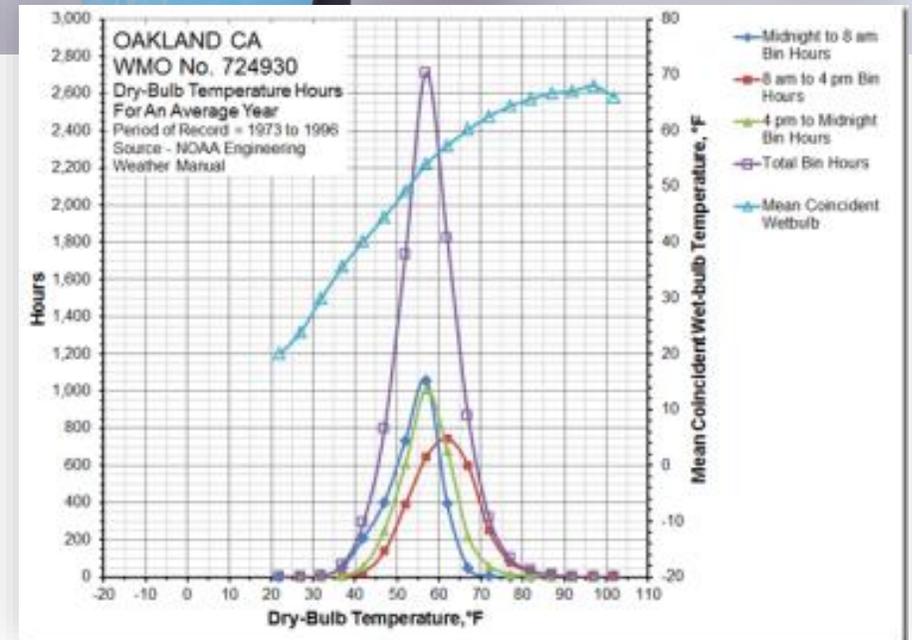
Bigger is Better

Stop oversizing.

VCHPs work better when they are at sized very closely to the heating requirement.

1. Use load calculation software
2. Set design temperature to 1%
3. Select equipment based off manufacturer's performance data

“OVERSIZING — Just don't do it”



FAIL #5

Too Many Heads

Ductless Related Issue

Ductless “heads” move more air than you think and can distribute conditioning widely.

Less is more because they condition and circulate constantly.

“Indoor units are not the same as registers/grills”



YOU CAN DO THIS!

1. Use the 4-step heat pump design process
2. Get load and ductwork design training
3. Use the TIPS; learn from the FAILS



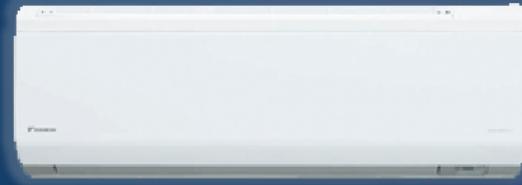
START NOW

And build your heat pump expertise!



PATH TO MASTERY

Install a heat pump in
your own home!



There is no more powerful statement than, *"After I installed one in my home...."*



THANK YOU!



Let's stay in touch!

Jonathan Moscatello

(503) 267-6425

jm@mainstreaminnovations.net

Linked in

www.MainstreamInnovations.net



HEAT PUMPS

DESIGNING HEAT PUMP INSTALLATIONS
FOR HEATING AND COOLING

