EEBA
Energy & Environmental Building Alliance

Lessons Learned from the Colorado Marshall Fire Part 2

Oct 2, 2024

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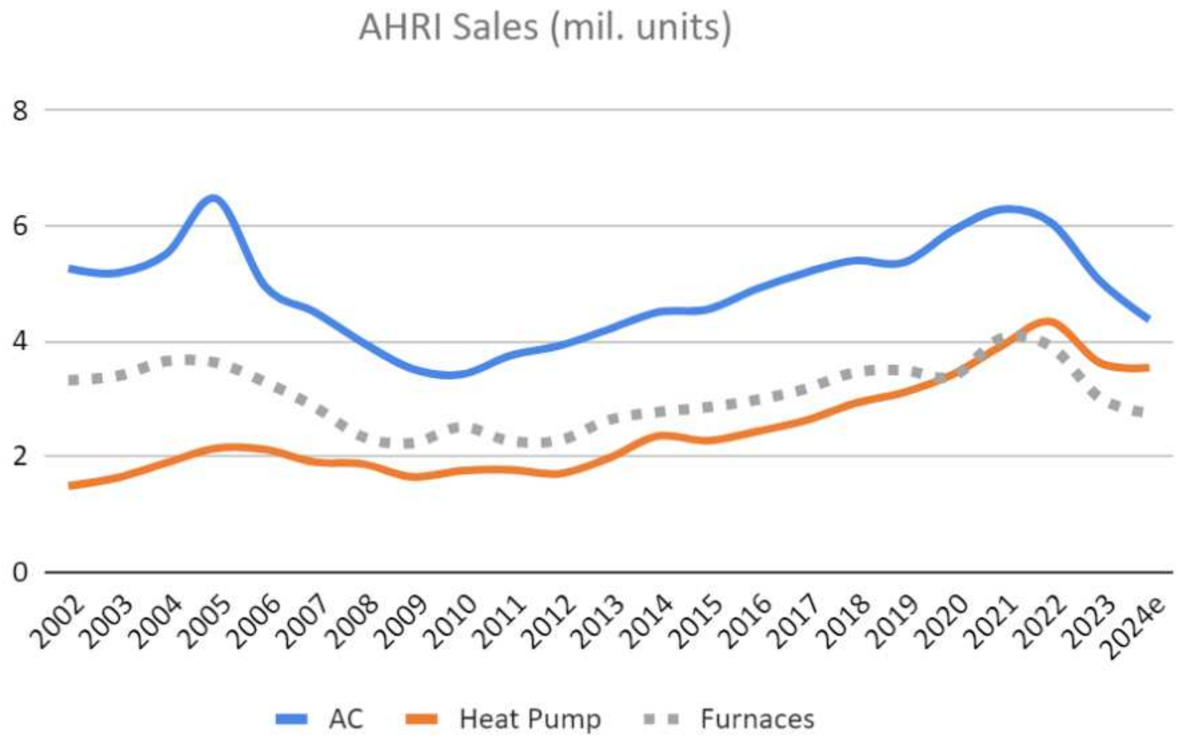
Topics To Cover

- ❑ Big Picture Thoughts
- ❑ ASHP Basics
- ❑ ccASHP Examples
- ❑ Specs & Field Data
- ❑ Panel Upgrade?

Joe P’s home (Fraser, CO)
“Installed 2015 and operates below -30°F”

Not talking about "those" heat pumps

HVAC Equipment Changes

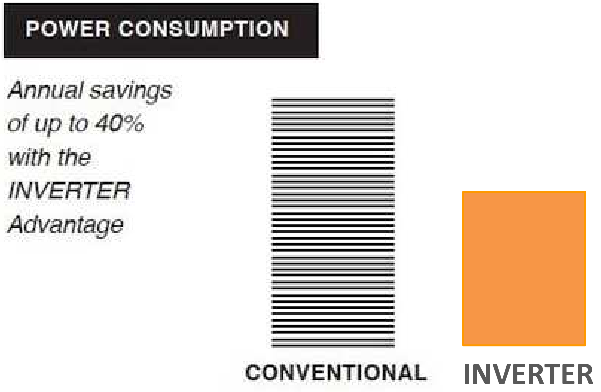


Heat Pumps Beating Furnaces

Heat pumps also provide cooling, and will soon overtake ACs

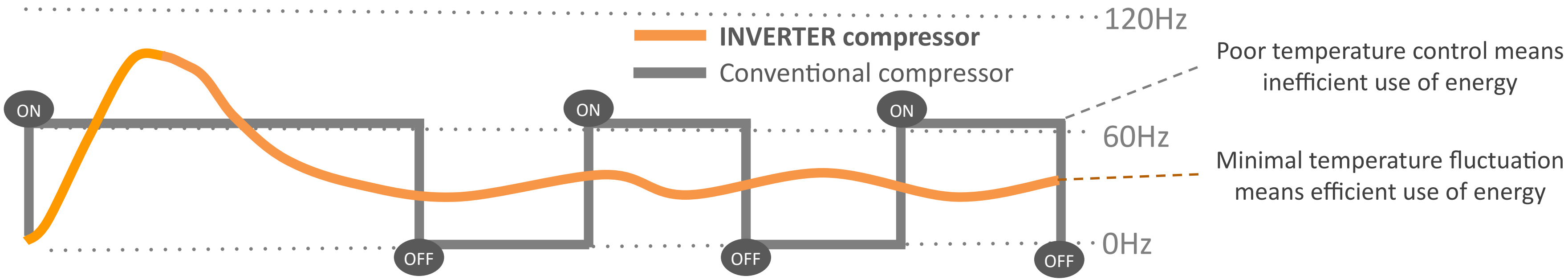
https://www.ahrinet.org/analytics/statistics/monthly-shipments

Efficiency, Durability, Comfort



Inverter-Based Heat Pumps

Variable-speed compressors use less energy to meet the actual load for the space at that time.



The Goldilocks Principle

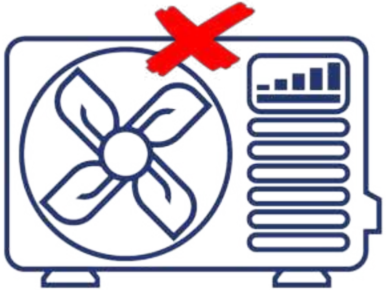
Too Small

System will not keep the house at setpoint when it should

- Backup heat needed?
- Slow recovery with t-stat setback
- Poor durability
- Poor energy efficiency

Just Right!

- Comfort
- Efficiency
- Durability



Too Big

System will cycle on and off more than needed

- Poor comfort
- Poor energy efficiency
- Poor durability
- More expensive

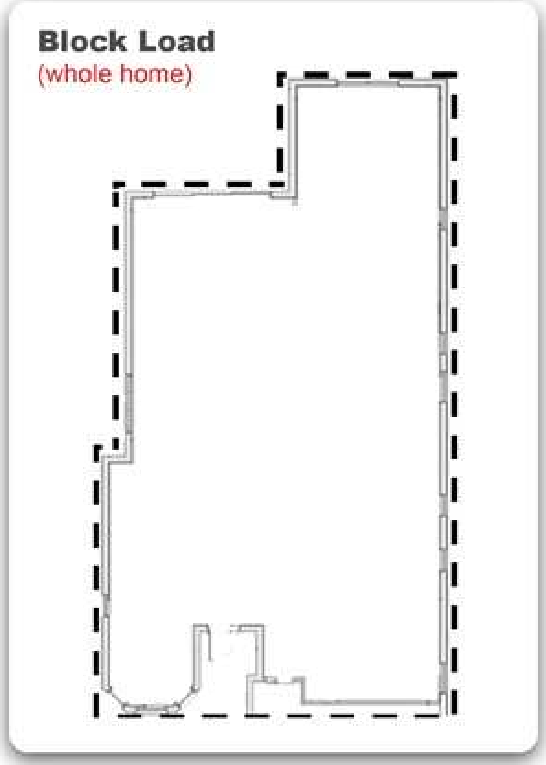
Equipment Options & Zones

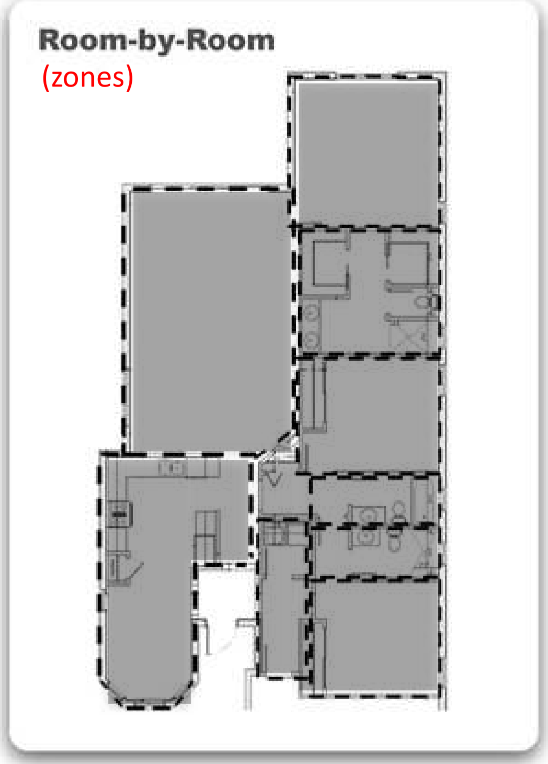
Single Zone

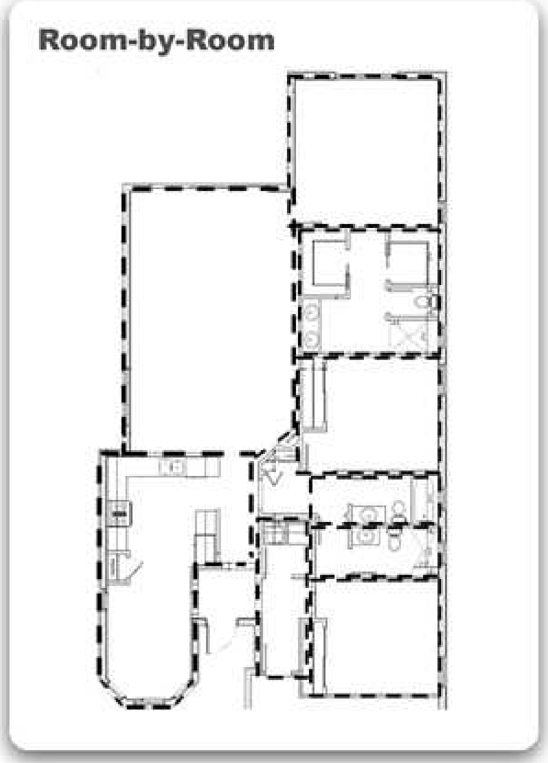
Multi-Zone (ported)

Multi-Zone (branch box)

Equipment Options & Zones

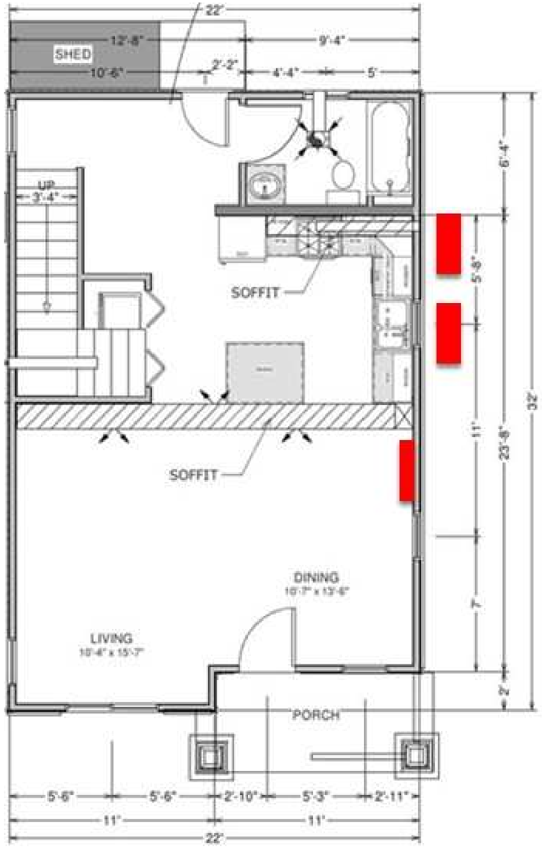


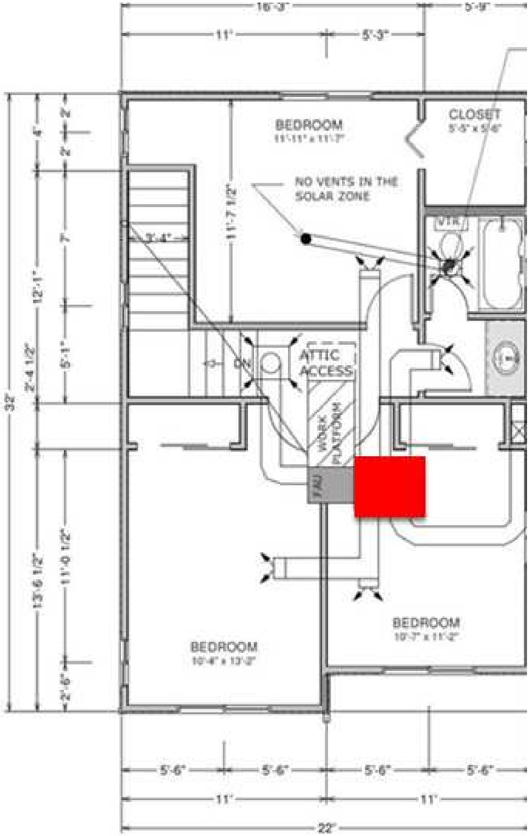




Ductless or Ducted or Both?

- Zoning, floor by floor
- Match the heat & cool load for smaller spaces
- Efficiency, comfort, & air quality
- Redundancy





Cold Climate ASHP Specs

Not all cold climate heat pumps are created equal

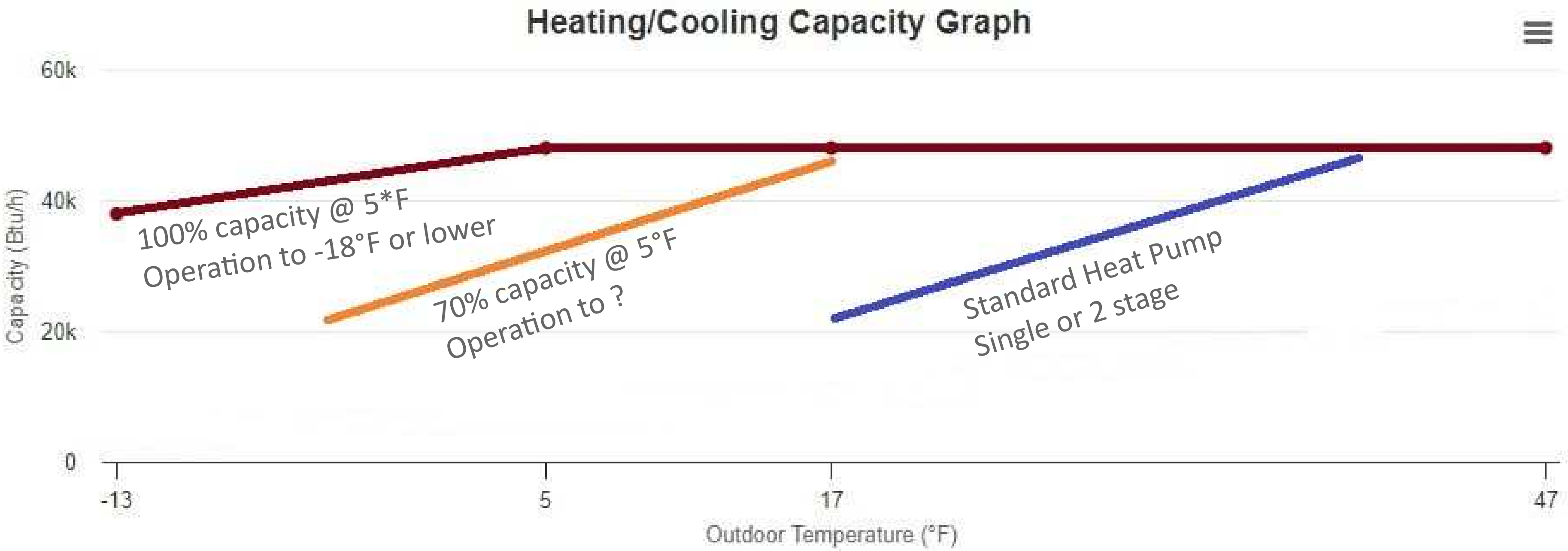
	CEE North, High Tier	**Energy Star** Cold Climate	**NEEP**	**Manufacturers**
Rated at 47°F & 17°F	✓	✓	✓	✓
SEER2 ducted, ductless	15.2, 16.0	15.2, 15.2	14.3, 15.0	✓
EER2 ducted, ductless	10.0, 9.0	**N/A**	✓	✓
HSPF2 (Reg IV) ducted - ductless	8.1, 9.5	8.1, 8.5	7.7, 8.5	✓
Capacity ratio at 5°F	58% or 70%	70%	✓	up to 100+%
COP at 5°F	1.75	1.75	1.75	✓
Capacity at -13°F or colder			✓	**Some**
Additional specs	energy mgmt	energy mgmt	3+ speeds	
Specification Link	[CEE Res HVAC 1/1/23]()	[CAC & HP v6.1 Jan-2022]()	[ccASHP v4.0 1/1/2023]()	

Air to water heat pumps are not yet rated per these agencies.

Cold Climate ASHP Specs

NEEP'S COLD CLIMATE AIR SOURCE Heat Pump List

Cold climate heat pumps are <u>purpose-built for cold weather</u>

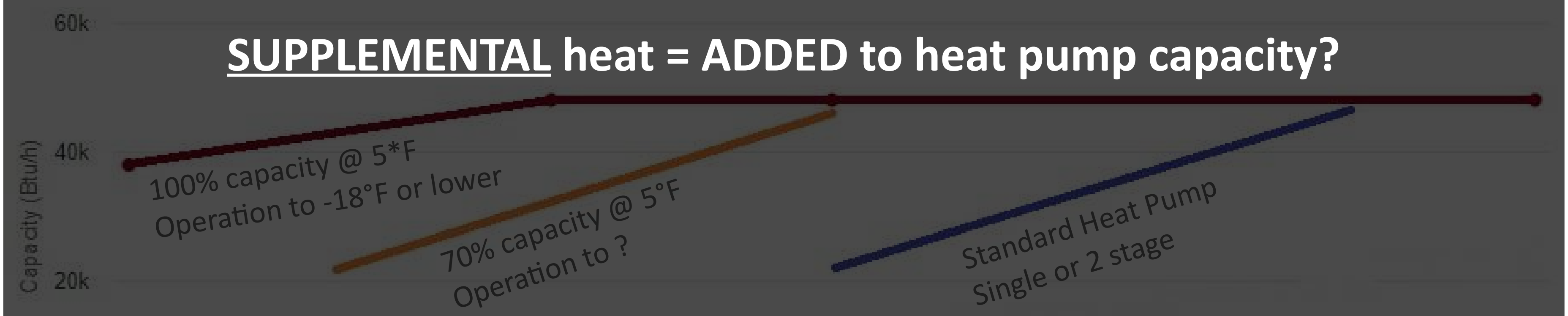


Cold Climate ASHP Specs

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

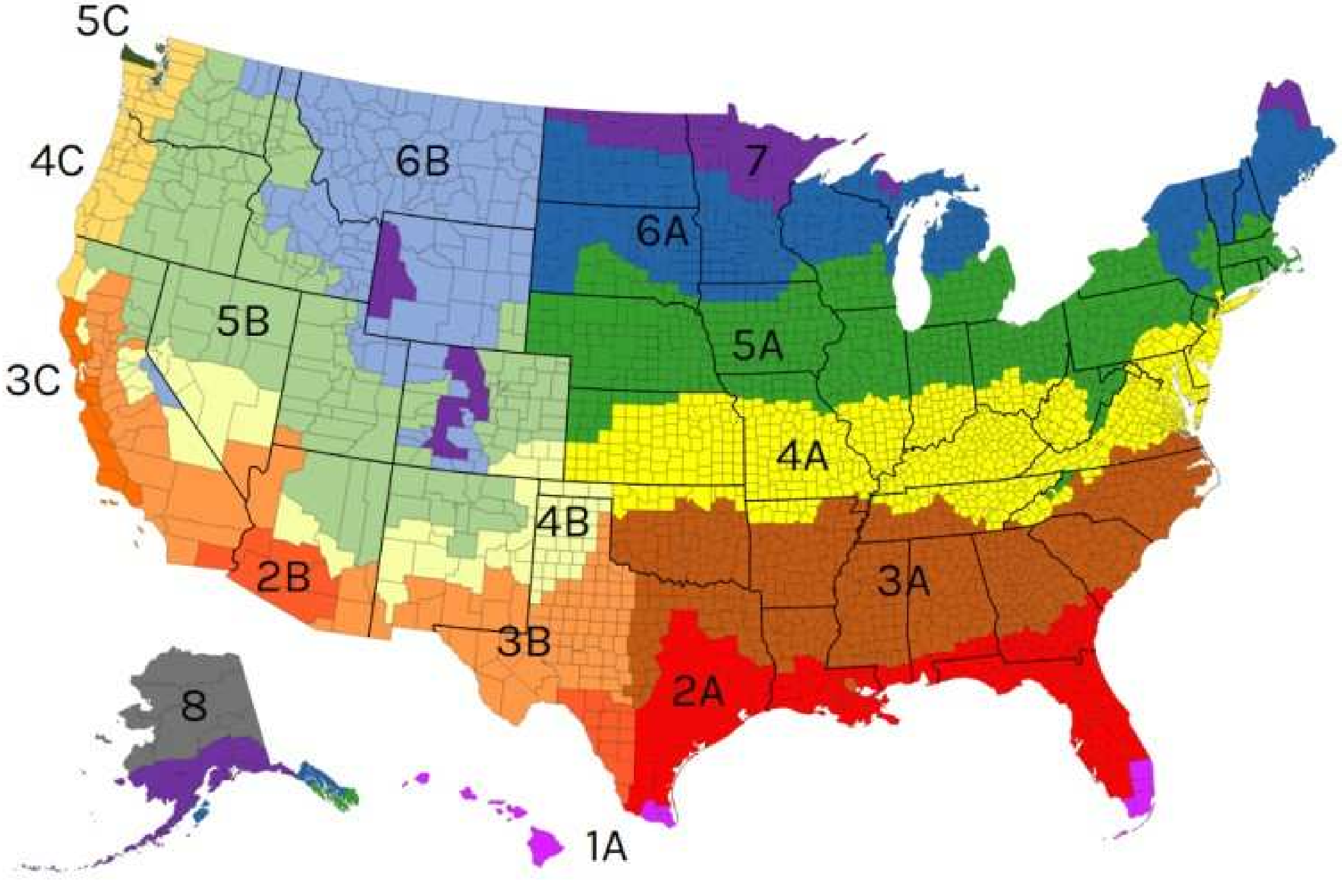
When do you need…

<u>SUPPLEMENTAL</u> heat = ADDED to heat pump capacity?



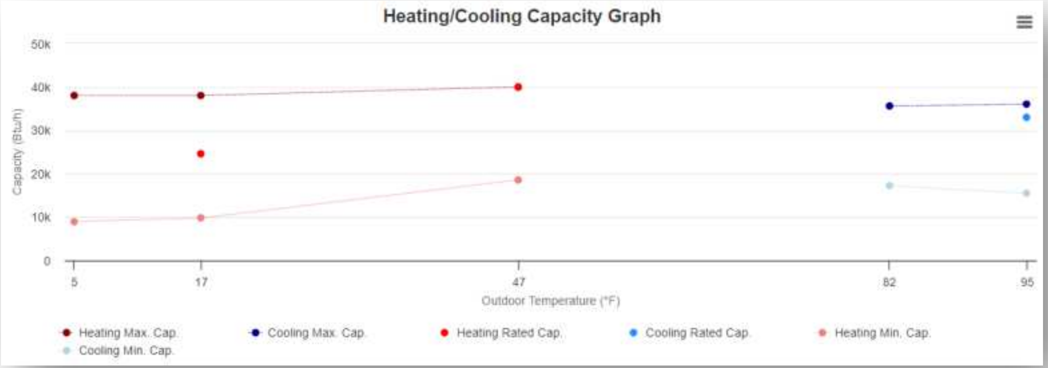
<u>BACKUP</u> heat = SWITCHOVER to another heating source, beyond the heat pump capacity?

Cold Climate ASHP Locations?

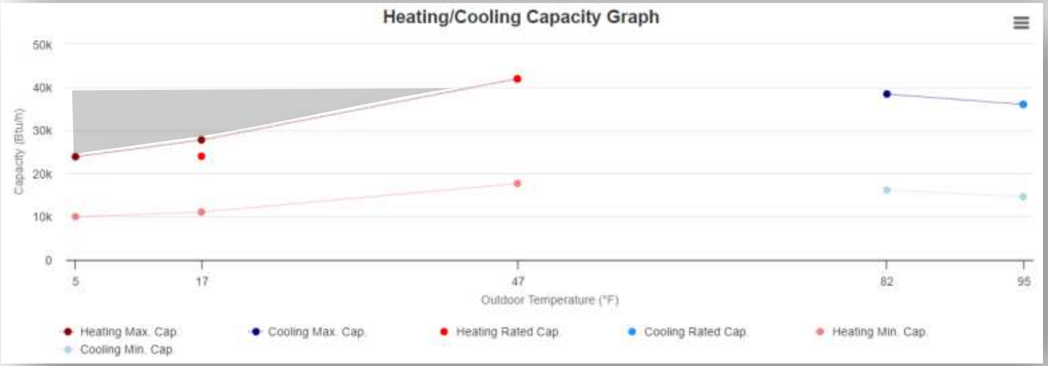


Double Check The Specs

Both are on the NEEP ccASHP list. Which one is right for the house?



Cold Climate
100% @ 5°F
80% @ -13°F
Opp @ -22°F



Standard
66% @ 17°F
57% @ 5°F
Opp @ -8°F

https://neep.org/heating-electrification/ccashp-specification-product-list

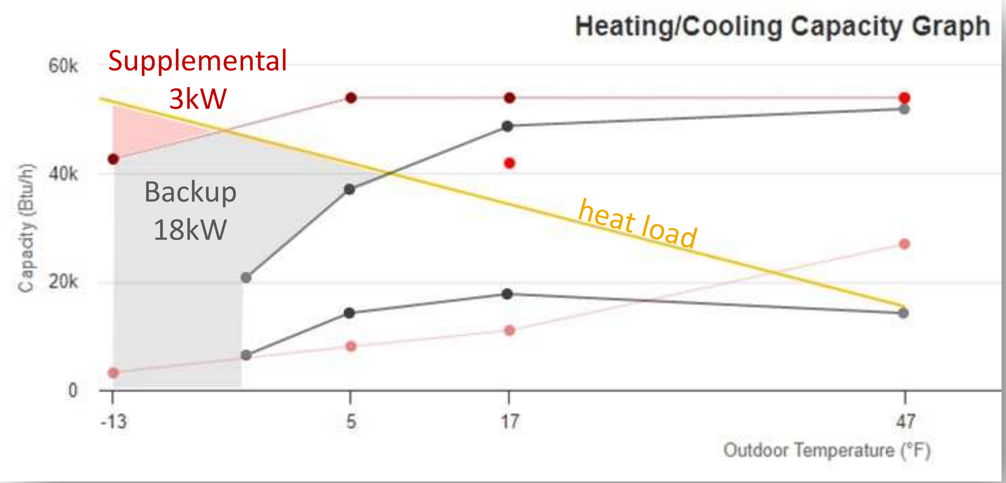
Double Check The Specs

Which is right for the client?

Multizone + 2 duct systems

23 SEER, 12 HSPF
54 kBTU/h @5°F
COP 1.9 @5°F

- **3kW heat strip below -4°F**
- Heat pump to -24°F
- Maintains efficiency
- **65A total breakers** (50A+15A)
- Supplemental



Two high efficiency ducted heat pumps

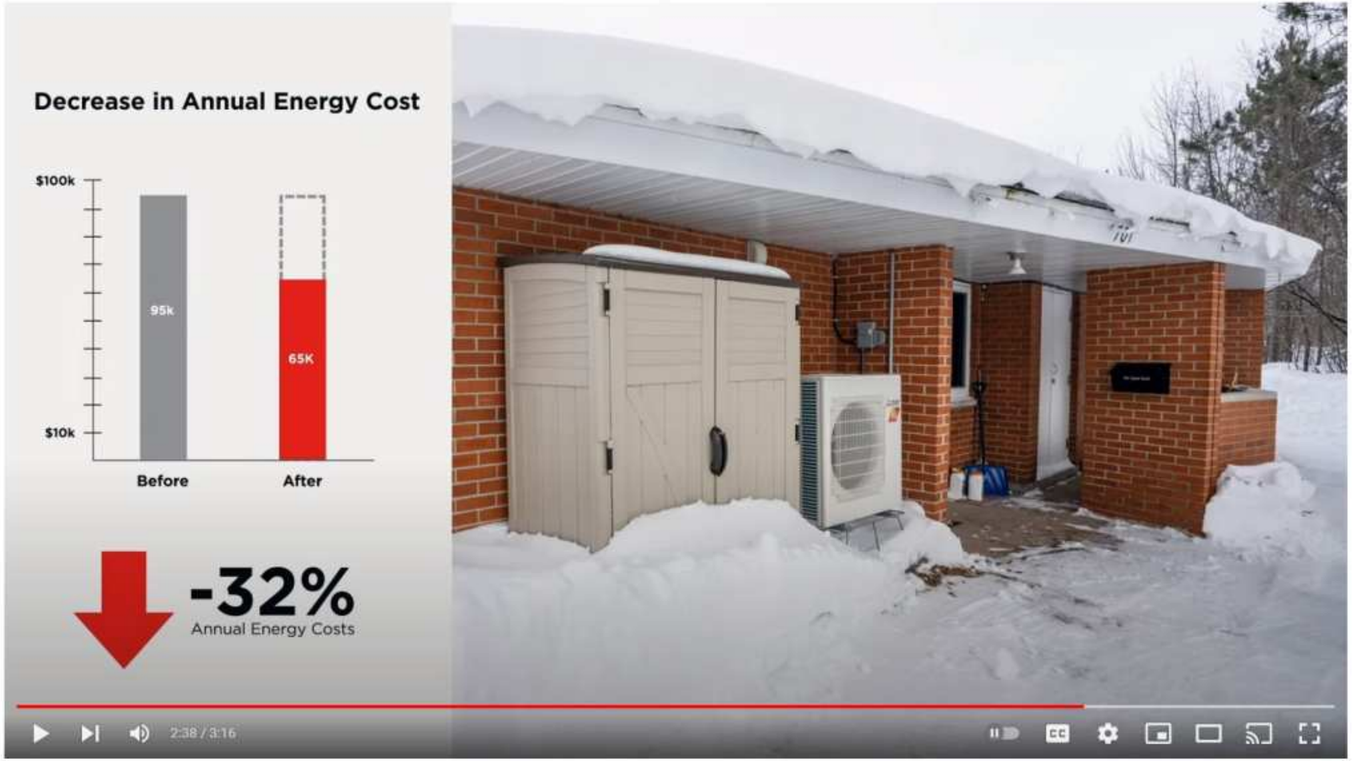
24 SEER, 13 HSPF
39 kBTU/h @ 5°F
COP 2.48 @5°F

- **18k heat strip below 9°F**
- Heat pump to -4°F
- Efficiency plummets
- **190A total breakers** (2x30A, 2x15A, 2x50A)
- BACKUP

The RIGHT heat pumps work when its cold

Ontonagon, MI
60 unit, 15 bldgs.

"**<u>25°F below zero</u>** temperatures and not a single tenant had any issue or even needed to turn on their electric resistance as backup."

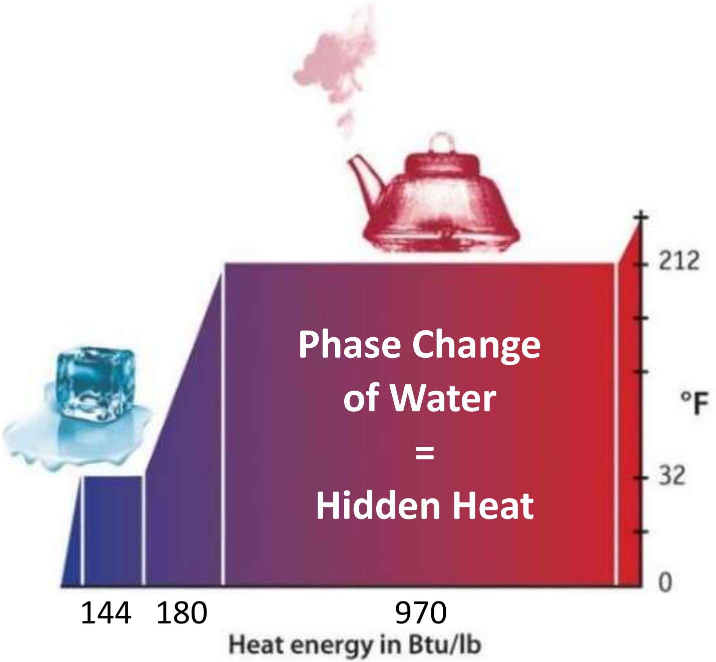


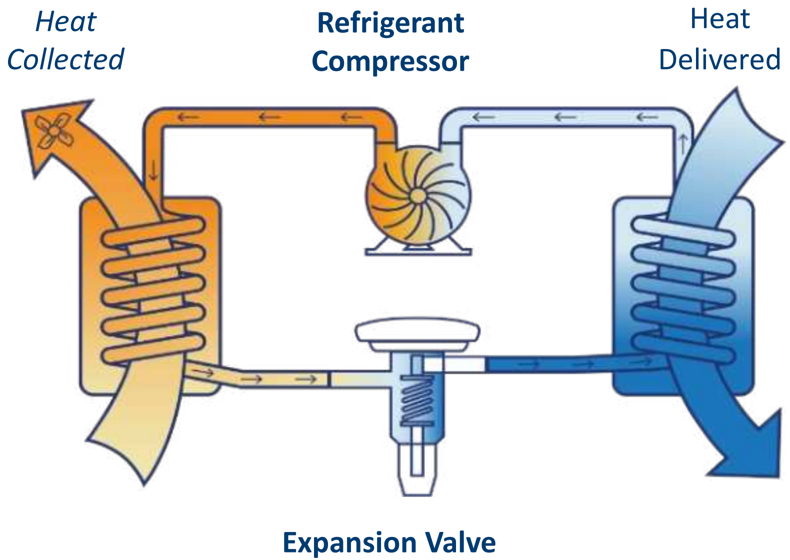
Project Profile: Ontonagon Village Housing

https://www.youtube.com/watch?v=6yyniDhmzO8

How Heat Pumps Work

Heat pumps use <u>phase change</u> to move heat





They manage temperature and pressure of the <u>boiling point of refrigerants</u>

Heat Pump Math

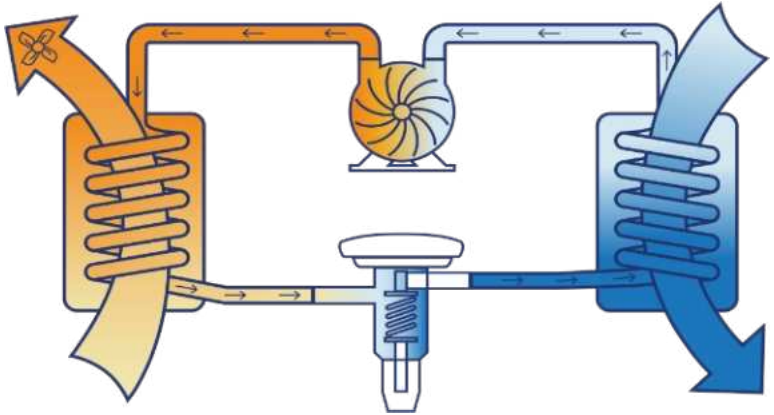
18,000 BTU
/ 3.412 BTU/W
/ ***4.0 COP***
= 1320 Watts input

Rated capacity @ 47°F

13,500 BTUh absorbed | 4,500 BTUh input | 18,000 BTUh delivered

13,500 BTUh from air
\+ 4,500 BTUh from compressor
= 18,000 BTUh delivered

18,000 / 4,500 = 4 COP



47°F outdoors
Evaporator

70°F indoors
Condenser

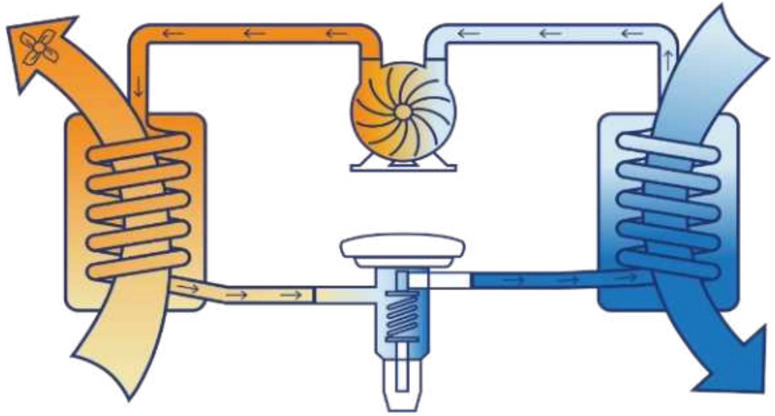
Heat Pump Math

100% capacity @ 5°F

```
 18,000 BTU
/ 3.412 BTU/W
/  2.0 COP
=  2640 Watts input
```

9,000 BTUh from air
+ 9,000 BTUh from compressor
= 18,000 BTUh delivered

18,000 / 9,000 = 2 COP



Heat Pump Math

70% capacity @ 5°F

```
 12,600 BTU
/ 3.412 BTU/W
/  2.5 COP
=  1480 Watts input
```

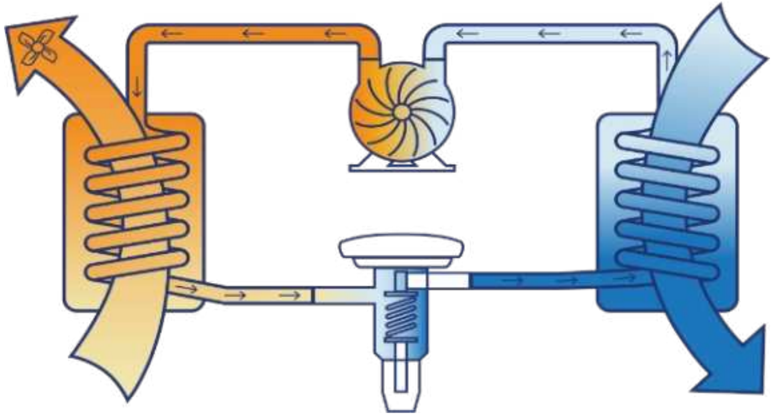
    7,600 BTUh from air
+   5,000 BTUh from compressor
= 12,600 BTUh delivered

12,600 / 5,000 = 2.5 COP

7,600 BTUh absorbed

5,000 BTUh input

12,600 BTUh delivered



5°F outdoors Evaporator

70°F indoors Condenser

Heat Pump Math

70% capacity @ 5°F

18,000 BTU
/ 3.412 BTU/W
/ ***1.7 COP***
= 3100 Watts input

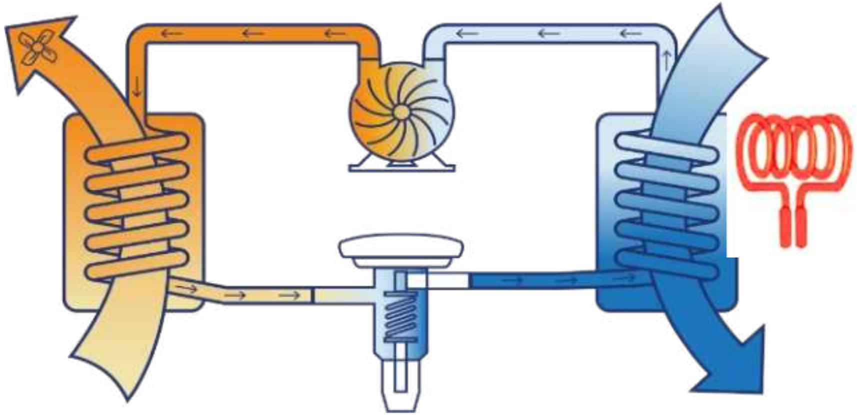
7,600 BTUh absorbed

5,000 BTUh
+5,400 BTUh
input

18,000 BTUh
delivered

    7,600 BTUh from air
+ 5,000 BTUh from compressor
= 12,600 BTUh delivered
+ 5,400 BTUh electric supplemental
= 18,000 BTUh total

18,000 / 10,400 = 1.7 COP



5°F outdoors
Evaporator

70°F indoors
Condenser

How cold does it operate?
Do you need full backup?

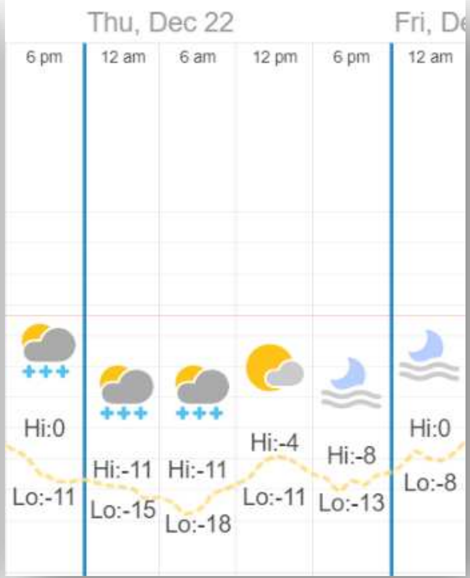
The RIGHT Heat Pump - Winter

```
  5500 Watt hrs avg
x 3.412 BTU/W
x   2.0 COP
= 37,500 BTU/h avg
```

4T ccASHP + 2 duct systems
200 amp SPAN panel

-18°F @ 8am 12/22/2022
Design temp 0°F
3700 sf home, 46 kBTU/h load

- ❖ Max ampacity 42A (10 kW)
- ❖ ***Stayed below 25A (6 kW)***
- ❖ Averaged 23A (5.5 kW)



The RIGHT Heat Pump - Summer

1420 Watt hrs avg
x 3.412 BTU/W
x ***3.2 COP***
= 15500 BTU/h avg

2.5T ccASHP + 1 duct system
100 amp panel

97°F @ 3pm, July 24, 2023
Design temp 95°F
1700 sf home, 20 kBTU/h load

- 1.8 kW for 14 mins
- 1.3 kW for 90+ mins
- 0.2 kW net w/ solar PV
- Avoided peak summer rates

- Max ampacity 24A (5.8 kW)
- ***Stayed below 8A (1.9 kW)***
- Averaged 5.9A (1.4 kW)

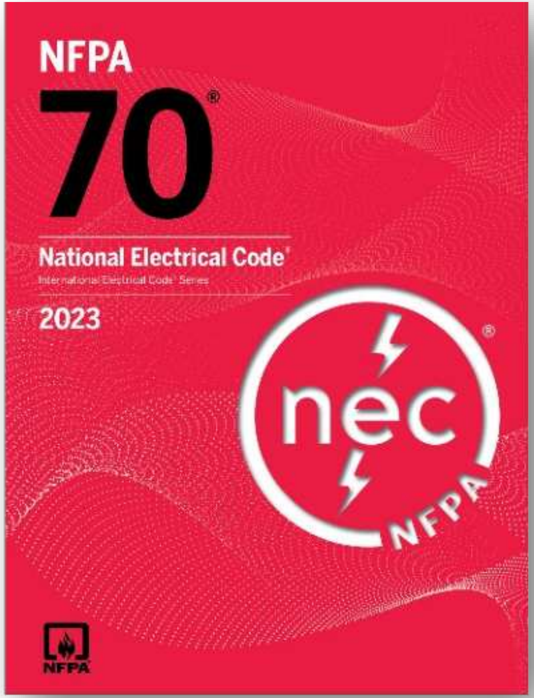
Also fully heats this home in winter

100A Breaker Panel Study

NEC 220.87 – Existing Loads
Connected Load Study

- Max demand over 1-year period
- Max demand at 125% plus new load
- Overcurrent / Overload protection per 240.4 and 230.90

- **<u>Exception</u>** – Record max demand in 15-minute intervals continuously over 30-days minimum, occupied space and include largest loads



https://link.nfpa.org/free-access/publications/70/2023

100A Breaker Panel Study

Almost All-Electric Home + EV

ENERGY MONITORING

B#		Bus A	Bus B		B#
1		A	B	Whole	2
3	Range A	40	B	Home	4
5	Range B	40	A	Surge	6
7		B	A	Protector	8
9	Furnace	15	15	LR, Bsmt Lt, Entry Lt	10
11	Hall Closet	20	30	EV, Dryer B	12
13	Micro, Gar, Bsm, Lav	15	30	EV, Dryer A	14
15	Kit E, Fridg	20	30	Heat Pump A	16
17	Kit W, GFI	20	30	Heat Pump B	18
19	MBR, Loft, Kit Lt	15	30	Solar B	20
21	Bed2, Ba, MClos	15	30	Solar A	22
23	Disposal	20	15	spare	24

100A Breaker Panel Study

Denver, CO

ENERGY MONITORING

15 min data per **NEC 220.87** over 23 months (64,600 periods)

Max Amps, Emporia	49.4	47.3	47.2	13.0	4.5	15.4	10.5	6.3	6.2	5.3	3.7	25.9	22.7
Max Watts	10977	5681	5665	3119	539	1846	1262	756	745	636	447	6206	5453
>90% of max	9	6	3	5	2	4	2	3	1	2	10	1070	11
	0.01%	0.01%	0.00%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.02%	1.66%	0.02%
>50% of max	2296	2238	1808	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	336	8407	818
	3.6%	3.5%	2.8%	0.3%	20.4%	0.9%	0.1%	0.9%	0.0%	0.0%	0.5%	13.0%	1.3%
Time Bucket	**Total kW**	**Vue2_A (**	**Vue2_B (**	**Stove 1,3**	**Furnace**	**Micro,Ga**	**Kit-e Frig**	**Kit-w GFI**	**MBR, Lo**	**Bed2, Ba**	**LR, Bmt**	**EV, Drye**	**ASHP 16**
11/18/22 21:00	11.0	5.7	5.3	0	0.3439	0.0556	0.02	0.0218	0.0026	0.0101	0.1034	5.7941	4.8698
1/25/24 6:15	10.6	5.448	5.145	0	0.3451	0.0563	0.0002	0.0169	0	0.0236	0.0327	5.7993	4.5324
11/17/22 6:30	10.4	5.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0413	5.7811	4.3543
11/17/22 6:15	10.1	5.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0411	5.7616	4.0272
1/25/24 5:15	10.0	5.1451	4.902	0	0.3428	0.0573	0.0844	0.0165	0	0.0052	0.0324	5.8029	3.9169
1/11/23 23:45	9.9	4.2	5.7	0.006	0.3417	1.5578	0.0152	0.023	0.0088	0.007	0.035	5.1592	2.7214
1/26/23 4:15	9.9	5.1	4.8	0	0.3407	0.0561	0.0344	0.0169	0.0029	0.0249	0.0334	5.8054	3.8106
1/26/23 6:15	9.9	5.1	4.8	0	0.2822	0.0595	0.0212	0.017	0.003	0.0044	0.0334	5.781	3.9234
1/26/23 5:15	9.9	5.1	4.8	0	0.3409	0.0564	0.0283	0.0169	0.0026	0.017	0.0334	5.8008	3.8172
1/26/23 3:00	9.9	5.1	4.8	0	0.3434	0.0565	0.0232	0.0171	0.0028	0.025	0.0336	5.8543	3.7307

<50 Amps max 15 minutes

9 periods within 90% of max

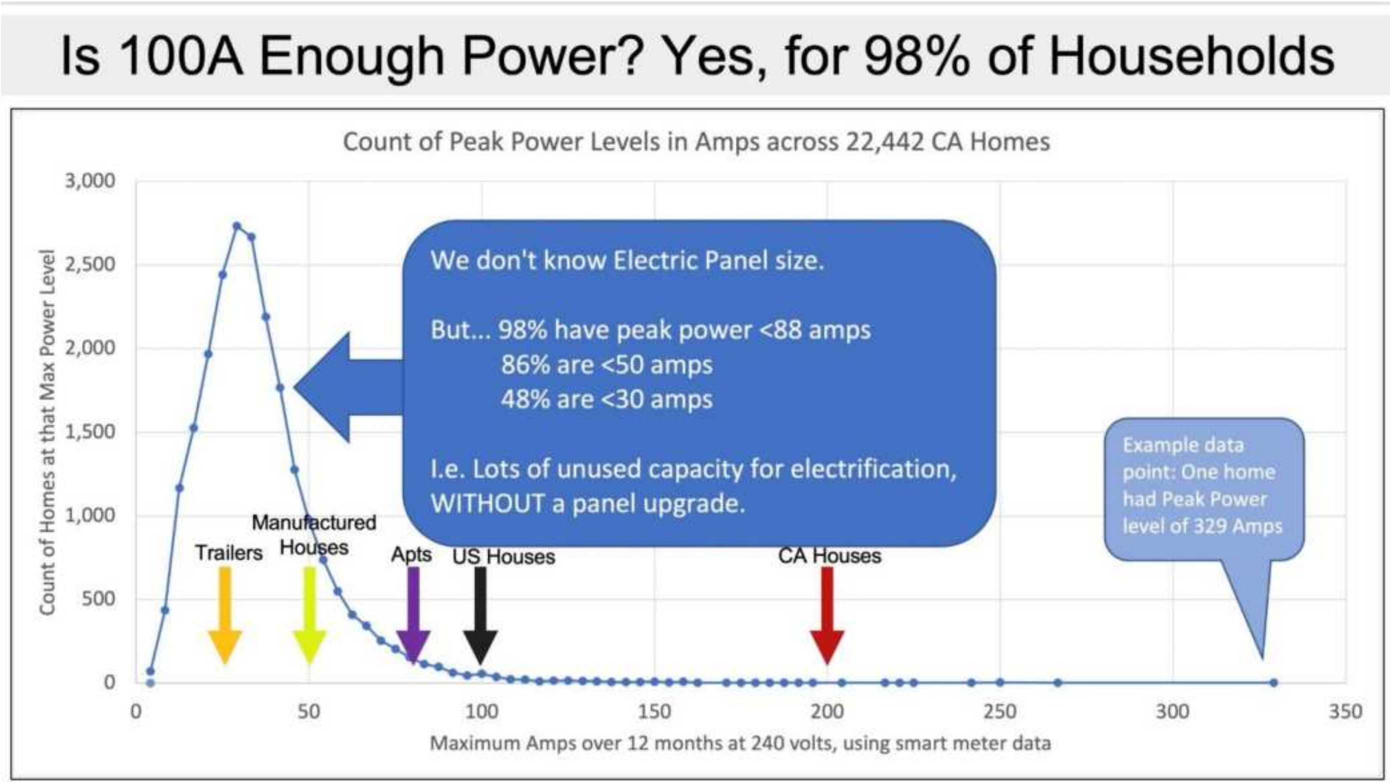
Panel Sizing

400 Amp
service panel?

… says who?
… and why?

Check their
assumptions

Panel Sizing

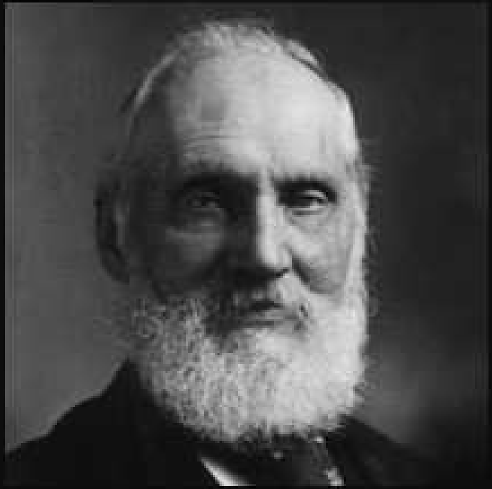


HOME ENERGY ANALYTICS

"Our analysis shows there is much greater panel capacity than has been commonly assumed."

https://corp.hea.com/home-electrification

Is a Panel Upgrade NEEDED?



If you can not measure it, you can not improve it.

~ Lord Kelvin

AZ QUOTES

Big Changes in 14 Years

1935

10%
Farms with Electricity

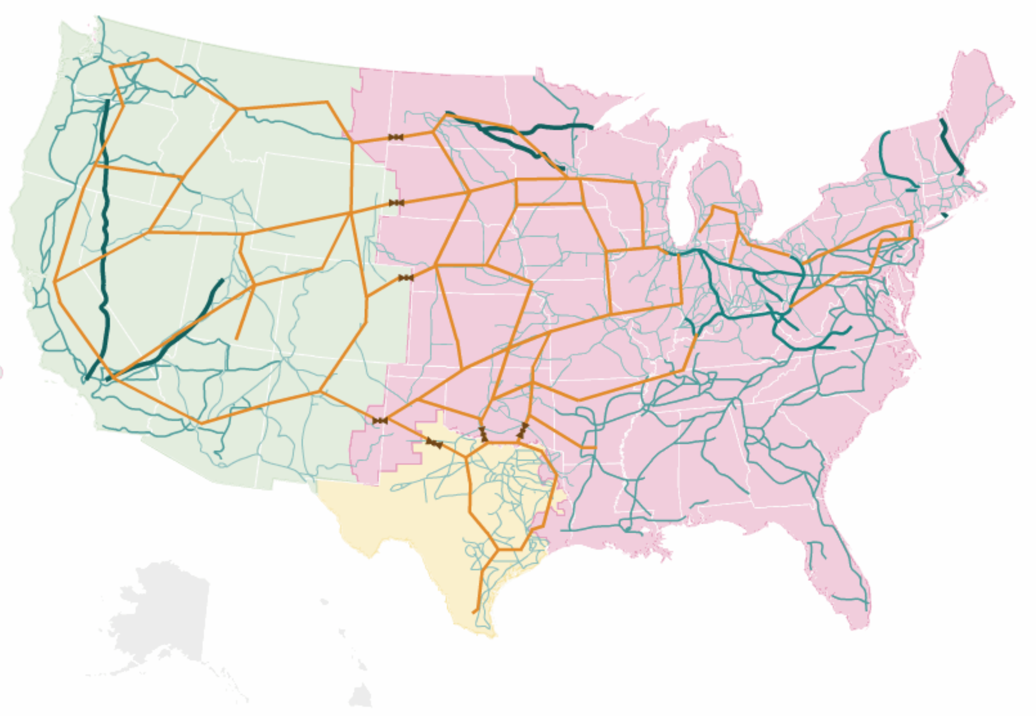
1949

70%
Farms with Electricity

Big Changes in 45 Years

1950

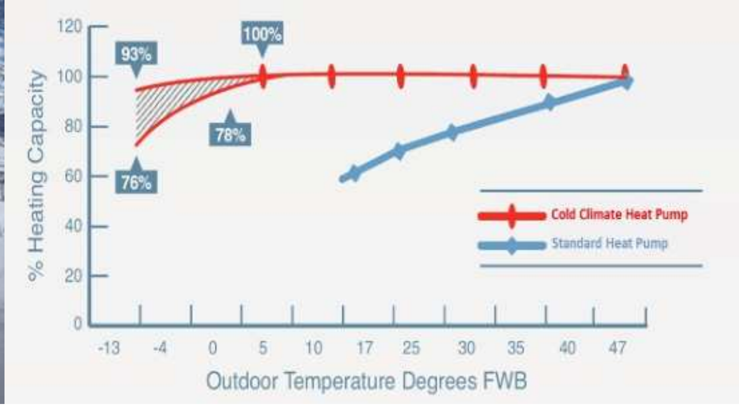
334 M kWh delivered



1995

3,353 M kWh delivered

https://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf



Robby Schwarz

Thank You!

#heatpumpnation
#betterHVAC

Shawn LeMons