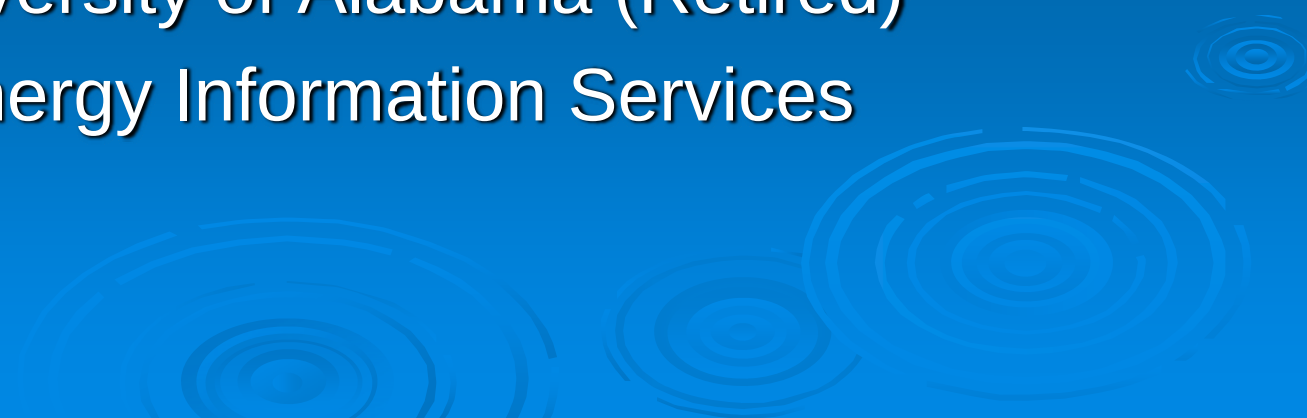


HVAC Equipment Ratings SEER, HSPF, EER, COP, kW/ton, and System Efficiency

Steve Kavanaugh
University of Alabama (Retired)
Energy Information Services



What is Seasonal Energy Efficiency Ratio?

AHRI 210/240 Optional Short Cut Rating Method

- Outdoor temperature: 82°F
- Indoor conditions: 80°F/67°F
- ESP
 - 0–28 MBtu/h 0.10" water
 - 29–42 MBtu/h 0.15" water
 - 43–65 MBtu/h 0.20" water
- No latent requirement
- Includes cycling degradation
- Might as well open the windows

Not so hot

Outside
Comfort zone

With 0.08"
Filter loss?

Know anyone
who designs
systems with
these ESPs?

SEER?

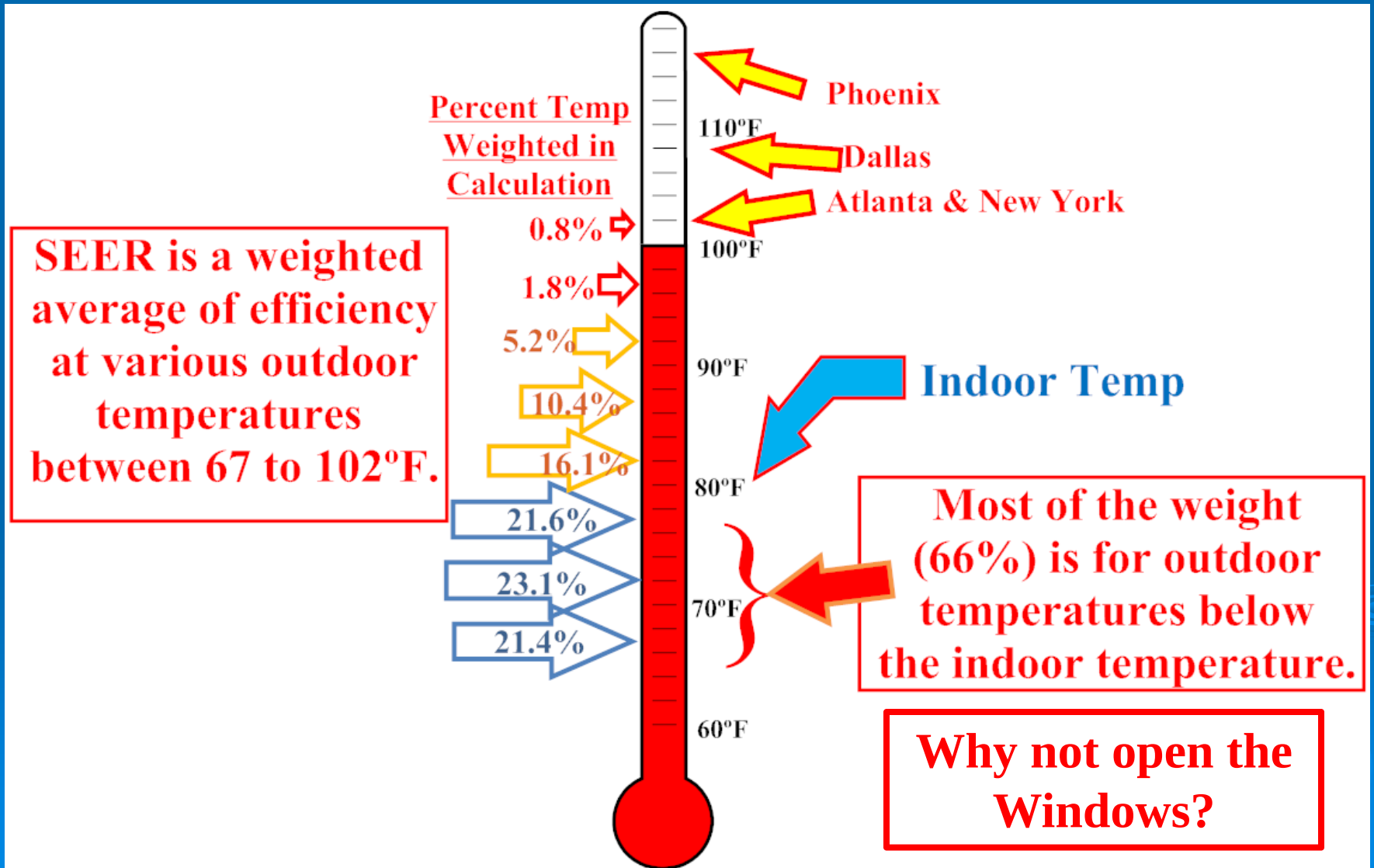
Why do some Heat Pumps with high Seasonal Energy Efficiency Ratios (SEER) have lower Energy Efficiency Ratio when the Outdoor Temperature is 95°F (EER₉₅)?

Outdoor Unit	Indoor Unit	Capacity	SEER	EER ₉₅
XL19i (2TWZ9036)	TWE040E13	3-ton	17.6	12.1
XL14i (2TTX4036)	TWE040E13	3-ton	15.0	12.9
XL19i(2TWZ9048)	TWE049E13	4-ton	16.6	11.4
XL14i (2TTX4048)	TWE049E13	4-ton	15.0	12.85
XL19i (2TWZ9060)	TWE065E13	5-ton	15.9	10.5
XL14i (2TTX4060)	TWE065E13	5-ton	14.0	11.9

Avg. SEER Change SEER 14 Units to SEER 19 = +13.7%

Avg. EER₉₅ Change SEER 14 Units to SEER 19 = -9.9%

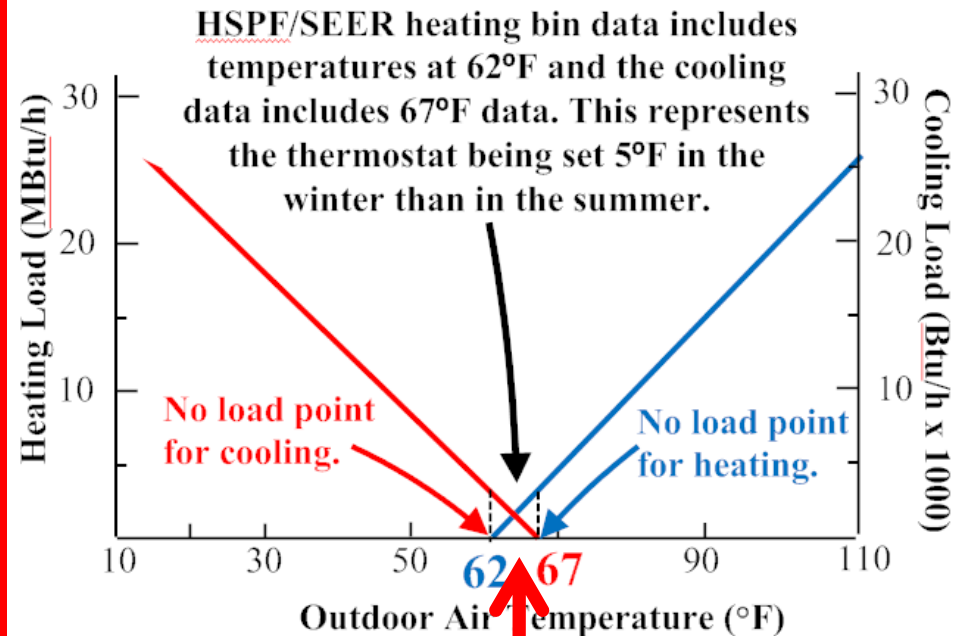
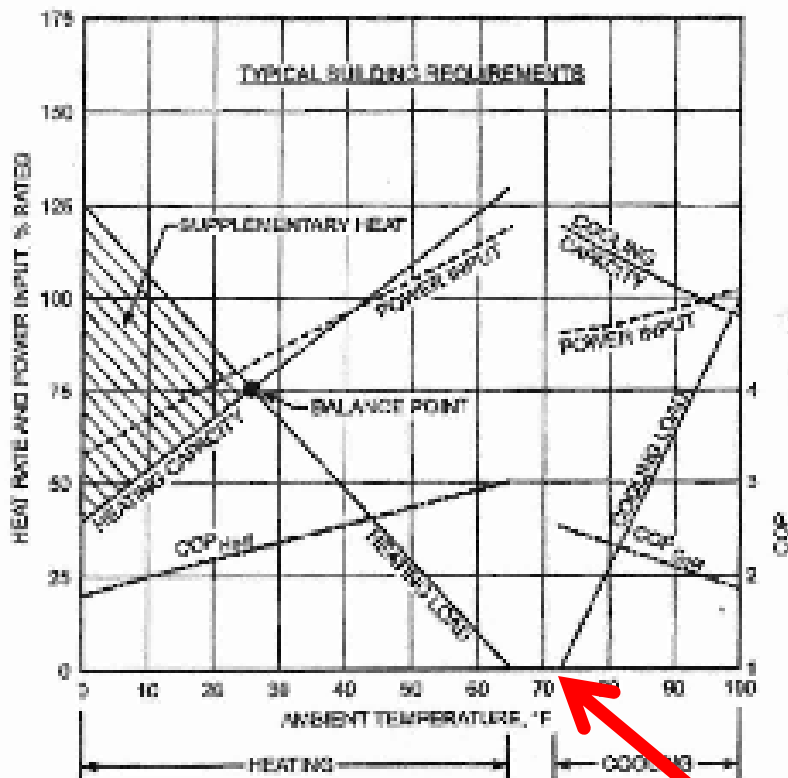
AHRI 210/240 SEER Rating Conditions When Using Bin Method Rating Procedure



HSPF/SEER Bin Data Assumes Thermostats Are Set 5°F Higher in Heating than in Cooling

ASHRAE Handbook

AHRI Std. 210/240



There should be a 10°F no-heat and no-cool dead band since indoor temp is 70°F in heating and 80°F in cooling.

AHRI 210/240 HSPF Rating Conditions

- Bin calculation is used
- Indoor conditions: **70°F/60°F**
- Climate Zone 4 temperature bins:

62°F(13.2%)	42°F(10.0%)	22°F(5.5%)
57°F(11.1%)	37°F(10.9%)	17°F(3.6%)
52°F(10.3%)	32°F(12.6%)	12°F(2.6%)
47°F(9.3%)	27°F(8.7%)	≤7°F(2.2%)

If ASHRAE procedures were used, these temperatures (34.6% of total) would not be used to find HSPF.

Internal heating extended to these conditions for commercial buildings.

Necessary Info Not Required to be Reported

Cooling			High Heating 47°F		Low Heating 17°F		Phase	AHRI Type	HSPF/TC	Exclusively For Export	Est. National Avg. Annual Operating Cost	
Capacity (Btu/h)	EER	SEER	Capacity (Btu/h)	HSPF	Capacity (Btu/h)						Cooling Cost (\$)	Heating Cost (\$)
45500	10.5	13.0	43300	8.50	29000		1	HRCU-A-CB			\$1286	978
48500	10.50	13.00	43300	8.50	29000		1	HRCU-A-C			417	978
44000	11.00	13.00	48500	8.50	29000		1	HRCU-A-CB			384	1090
45500	11.00	14.00	48500	8.50	29000		1	HRCU-A-CB			379	1090
48000	11.00	14.00	48500	8.50	29000		1	HRCU-A-C			383	1090
45500	11.00	14.00	48500	8.50	29000		1	HRCU-A-C			379	1090
45500	12.00	14.00	43300	8.50	29000		1	HRCU-A-CB			379	978

EER 95 with 80°F Indoor Temp & 0.15" ESP

Don't Know if SEER Derived from Short Cut or Bin Method Calculation

COP Values Not Reported Only HSPF & Heating Capacity Reported

Manufacturer's Data for Older & Newer Equipment

Why No kW info?

50HJQ005 (4 Tons)								
Temp (F) Outdoor Entering Air (Edb)		R-22	Indoor Entering Air — Clim/BF					
			1200/0.1			1600/0.12		
			Indoor Entering Air — Ewb (F)					
		72	67	62	72	67	62	
75	TC	51.0	48.9	43.9	52.3	50.2	46.0	
	SHC	24.1	33.1	40.3	26.0	37.0	44.2	
	KW	2.63	2.64	2.60	2.66	2.63	2.61	
85	TC	48.9	47.1	41.9	50.7	48.4	44.2	
	SHC	22.9	32.2	40.2	25.4	36.4	43.4	
	KW	2.99	2.98	2.94	3.01	3.00	2.96	
95	TC	47.1	45.1	39.2	49.0	46.3	42.1	
	SHC	22.3	31.3	39.2	24.9	35.6	42.1	
	KW	3.37	3.37	3.31	3.40	3.38	3.34	
105	TC	44.9	42.9	37.3	46.8	44.1	40.3	
	SHC	21.3	30.7	37.3	24.1	34.8	40.3	
	KW	3.79	3.78	3.71	3.82	3.80	3.73	
	TC	42.9	40.9	35.3	44.6	41.9	38.1	
	SHC	20.7	29.7	35.3	23.4	33.4	38.1	
	KW	4.21	4.20	4.13	4.24	4.22	4.15	

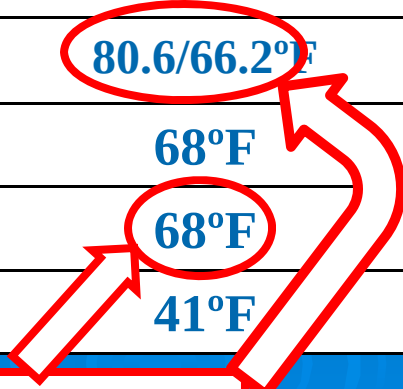
50HC 006				AMBIENT TEMPERATURE												
				95			105			115						
				EAT (db)			EAT (db)			EAT (db)						
				75	80	85	75	80	85	75	80	85	75	80	85	
1500 Cfm	EAT (wb)	58	THC	53.8	53.8	60.7	51.7	51.7	58.3	49.4	49.4	55.8	46.9	46.9	53.0	
			SHC	46.9	53.8	60.7	45.0	51.7	58.3	43.0	49.4	55.8	40.9	46.9	53.0	
		62	THC	56.2	56.2	58.3	53.5	53.5	57.0	50.6	50.6	55.5	47.5	47.5	53.9	
			SHC	42.6	50.5	58.3	41.3	49.1	57.0	39.9	47.7	55.5	38.4	46.2	53.9	
		67	THC	61.7	61.7	61.7	58.7	58.7	58.7	55.5	55.5	55.5	52.0	52.0	52.0	
			SHC	35.1	43.0	50.9	33.8	41.7	49.6	32.5	40.4	48.3	31.1	38.9	46.8	
		72	THC	67.7	67.7	67.7	64.4	64.4	64.4	60.9	60.9	60.9	57.1	57.1	57.1	
			SHC	27.4	35.3	43.3	26.1	34.1	42.0	24.8	32.7	40.7	23.4	31.3	39.2	
				THC												
				SHC												
				THC												
				SHC												

GSHP Ratings

Good News: Performance is reported for multiple entering liquid temperatures (ELTs) in both heating and cooling

Bad News: Fan power assumes 0.0 in. ESP, pump power assumes 0 ft. water, indoor temp 80.6°F in cooling, and part-load performance at mild temps and enormous air flow rates

	Water Loop (WLHP)	Ground Water (GWHP)	Ground Loop (GLHP)
ELT(Cooling)	86°F	59°F	77°F
ELT(Heating)	68°F	50°F	32°F
EAT(Cooling-db/wb)	80.6/66.2°F	80.6/66.2°F	80.6/66.2°F
EAT(Heating)	68°F	68°F	68°F
		Part-Load Out ELT_c	68°F
		Part-Load Out ELT_h	41°F



Part Load EER can be very high since pumping heat from low temp to high temp is similar to pumping water downhill

Part-load EERs for Variable-Speed HPs are obtained with 59°F or 68°F condenser water, 80.6°F return air, 930 to 1200 cfm/ton airflow, 0.0 in. of external fan pressure, 0.0 ft. of water pump head

AHRI/ISO 13256-1 Performance Ratings

Variable Speed ECM Motor

AHRI/ASHRAE/ISO 13256-1

English (IP) Units

Model	Capacity Modulation	Flow Rate Clg/Htg	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
			Cooling EWT 86°F		Heating EWT 68°F		Cooling EWT 59°F		Heating EWT 50°F		Cooling Full Load 77°F Part Load 68°F		Heating Full Load 32°F Part Load 41°F	
		cfm	Capacity Btu/h	EER Btu/h per W	Capacity Btu/h	COP	Capacity Btu/h	EER Btu/h per W	Capacity Btu/h	COP	Capacity Btu/h	EER Btu/h per W	Capacity Btu/h	COP
036	Full	1300/1500	32,000	18.0	50,000	5.3	38,000	31.5	41,000	4.6	36,000	22.0	32,000	3.5
	Part		11,000	21.0	17,000	7.5	13,000	47.2	14,000	5.9	14,000	37.0	13,000	5.3
048	Full	1500/1800	41,000	17.6	67,000	5.0	49,000	31.7	55,000	4.3	46,000	21.7	43,000	3.6
	Part		16,000	22.5	24,000	7.6	19,200	53.2	19,000	5.9	19,000	41.0	16,000	5.3
060	Full	1800/2200	50,000	16.3	78,000	4.8	60,000	28.6	65,000	4.3	56,000	19.4	51,000	3.5
	Part		20,000	21.7	29,000	7.5	23,200	45.8	23,000	6.0	23,000	36.0	20,000	5.1

Cooling capacities based upon 80.6°F DB, 66.2°F WB entering air temperature

Heating capacities based upon 68°F DB, 59°F WB entering air temperature

All ratings based upon 208V operation

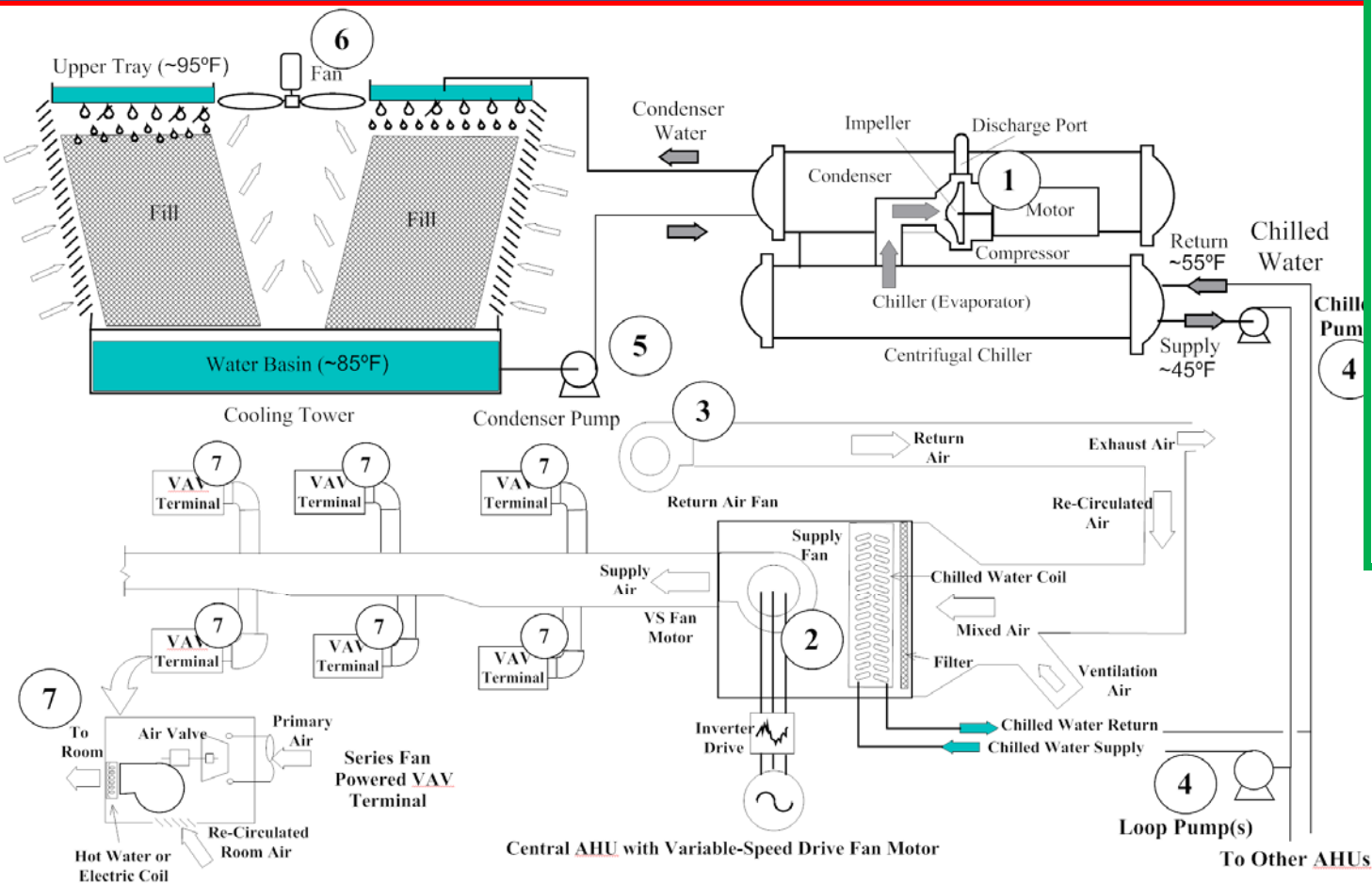
6/15/12

Constant Speed Heat Pumps Have the Highest Efficiencies at “Realistic” Operating Conditions

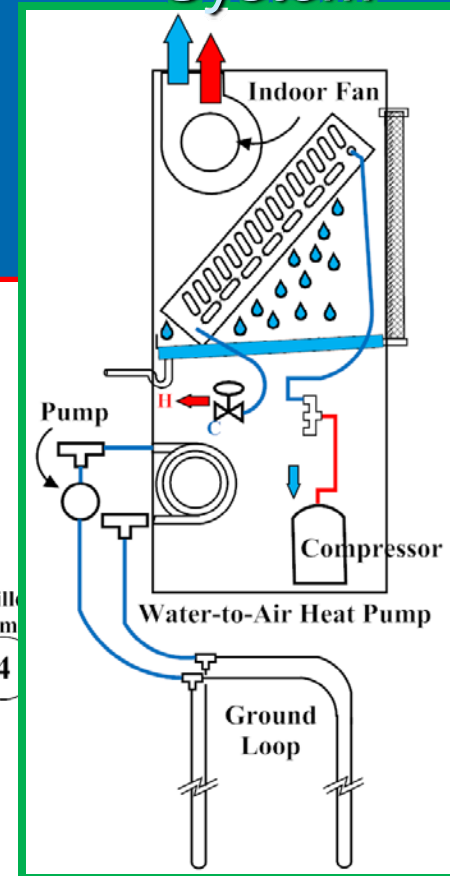
Water-to-Air Heat Pump Full-Load TC(kBtu/h), EER, HC(kBtu/h) & COP						
Cooling: 86°F EWT & 80.6/66.2°F EAT - Heating: 50°F EWT & 68°F EAT						
Model/Capacity	Cfm	TC	EER	Cfm	HC	COP
NS-036/Single	1200	34.5	19.6	1200	30.3	5.2
NS-048/Single	1500	47.0	17.5	1500	45.1	4.8
NS-060/Single	1800	64.3	17.2	1800	55.1	4.7
Average EER			18.1			4.9
ND-038/Dual	1200	39.0	17.2	1200	34.8	5.0
ND-049/Dual	1500	48.3	15.8	1500	47.2	4.7
ND-064/Dual	1800	64.5	16.2	1800	56.8	4.6
Average EER			16.4			4.8
NV-036/Variable	1300	32.0	18.0	1500	41.0	4.6
NV-048/Variable	1500	41.0	17.6	1800	55.0	4.3
NV-060/Variable	1800	50.0	16.3	2200	65.0	4.3
Average EER			17.3			4.4

Larger Non-Unitary HVAC Has No SYSTEM Efficiency Ratings Only Component Ratings Available

Chilled Water VAV



GSHP System



System Efficiencies Include All Components

Chilled Water VAV

- Screw Chiller* - 118 kW
(168 ton gross, 142 ton net)
- AHU Fans - 44 kW
- VAV fans - 14 kW
- Return fans - 21 kW
- ChW pumps - 12 kW
- Tower fan - 3 kW
- Cond. Pumps - 13 kW
- CW-VAV total - 225 kW

W-A Heat Pump GSHP*

- WAHPs (56)*- 118 kW
(168 ton gross, 163 ton net)
- HP Fans - 18 kW
- Grn. pumps - 10kW
- GSHP Total - 146 kW

HEAT

kW/ton = 0.90, EER = 13.4

kW/ton = 1.58, EER = 7.6

Summary

- SEER & HSPF (ASHPs), Part-Load (GSHPs), and kW/ton (chillers) ratings are for marketing purposes, should be ignored and not used for engineering calculations
- Useful reported values are limited, difficult to locate, and typically do not reflect conditions in the field
- For ASHPs, Cooling TC and EER at 95°F OAT and Heating HC and COP at 17°F OAT are recommended indicators for comparison but must be corrected for realistic air flow rates and fan pressures.
- For GSHPs, Cooling TC and EER at 86°F ELT and HC and COP at 50°F or 32°F ELT are the recommended indicators for comparison but must be corrected for realistic air flow rates, fan pressures and pump power.
- The demand of auxiliary components for non-unitary HVAC systems is significant and system efficiency is determined using total input power and corresponding heat penalties.