What Utility Planners Need to Know About SEER vs. (True) EER

Michigan D & I Workgroup
June 17, 2013
Lansing, Michigan

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ClimateMaster

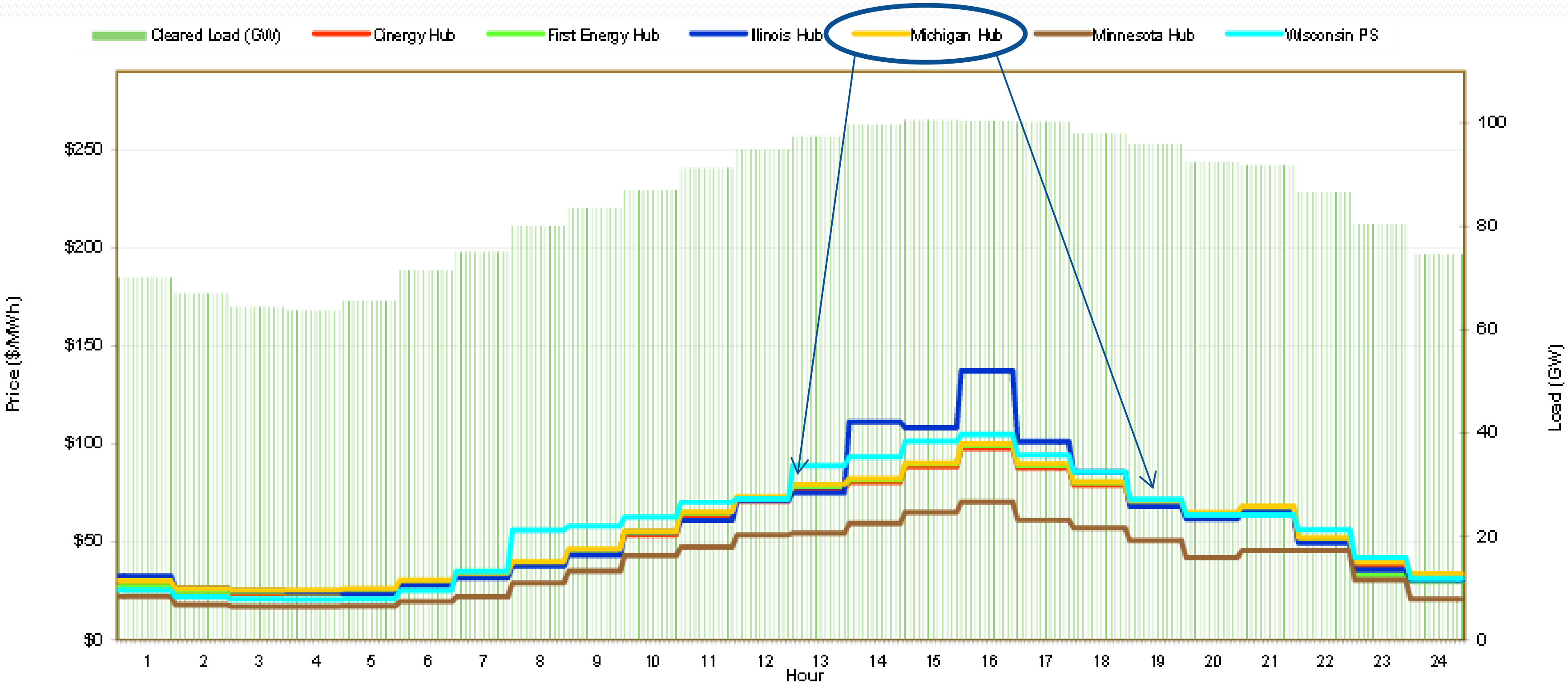
Let’s start with a survey……

The “S” Does not Represent SEER!

Do You Worry About:

- Summer Peak Demand?
  - Wind does not back the peak,
    - The wind doesn't blow in Texas when it is 110 out
  - Solar PV may not back the peak -
    - The sun is not very powerful after 4 PM
  - HVAC rebates based on SEER will not save the day
    - But they will make things worse......

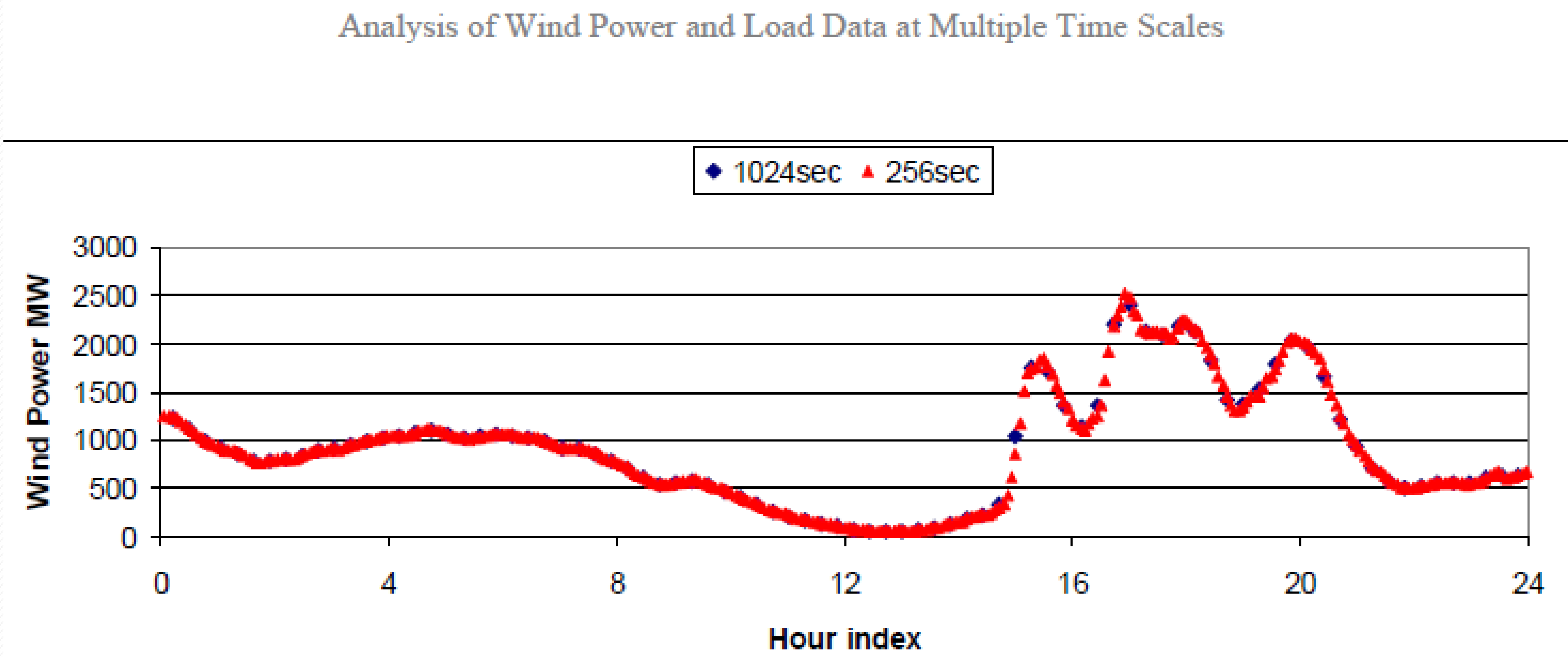
Utility workers are expecting triple-digit temperatures Friday as they work to restore electricity to thousands of Michigan homes and businesses that are still without power….The forecast calls for temperatures to hit or surpass 100 degrees in several cities including Detroit, Grand Rapids and Lansing….



Preliminary Real-Time Prices with Forecasted and Actual System Load

																								Avg. Hr $	
Hour Ending:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	All	On Pk
Cinergy Hub	26.93	24.63	24.27	24.12	24.86	25.72	27.43	41.91	50.99	41.97	62.78	86.24	61.17	66.23	75.08	94.18	75.99	60.47	57.56	45.09	44.99	33.12	35.17	31.53	47.60	58.31
First Energy Hub	26.96	24.78	24.52	24.37	25.12	25.88	27.50	42.07	51.35	42.37	63.57	87.66	84.65	94.56	81.43	86.18	76.12	68.09	58.78	45.84	45.66	33.57	35.51	31.93	50.35	62.34
Illinois Hub	26.63	24.14	23.68	23.46	23.93	24.86	26.92	41.42	50.23	41.49	62.12	85.19	60.28	62.37	61.09	68.32	65.94	59.70	56.67	44.48	44.36	32.82	34.73	30.76	44.82	54.46
Michigan Hub	28.38	26.02	25.62	25.47	26.33	27.17	28.98	44.31	53.63	43.53	64.65	88.49	63.24	65.67	62.95	67.80	65.94	61.02	58.25	45.85	46.00	34.10	36.58	33.25	46.80	56.38
Minnesota Hub	24.48	22.10	21.37	21.19	21.71	22.91	25.04	38.33	43.10	35.17	56.22	74.95	50.81	52.66	53.85	61.65	60.24	55.18	48.84	40.52	35.11	30.90	32.71	23.65	39.70	48.14
Wisconsin PS	27.63	25.14	24.52	24.11	23.98	25.15	54.68	86.51	87.99	58.82	130.79	198.19	56.79	57.72	59.20	69.80	68.29	61.85	51.66	45.02	37.64	33.93	36.28	30.41	57.34	71.28

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
Analysis of Wind Power and Load Data at Multiple Time Scales
December 2010

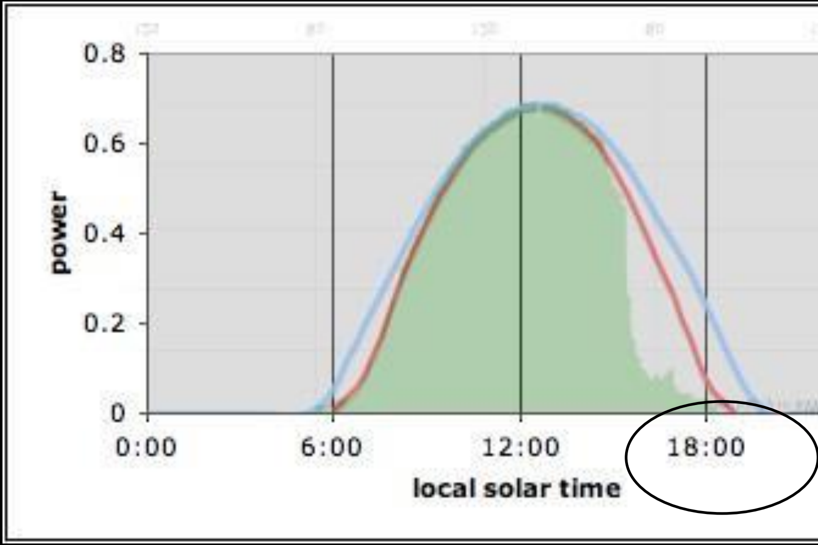


HVAC Peaks Vs. Solar PV

The warmest time of the day isn't high noon. Instead, it's usually between 3:00 and 6:00 p.m., and the high is usually recorded between 5:30 and 6:00 p.m. -wiseGEEK

HVAC System
Peak Time
1/4/10 19:00
2/20/10 20:00
3/25/10 21:00
4/28/10 18:00
5/17/10 18:00
6/27/10 18:00
7/23/10 18:00
8/4/10 18:00
9/25/10 18:00
10/14/10 18:00
11/28/10 19:00
12/17/10 19:00

Louisville KY
eQuest whole house
Time of HVAC peak



Source- Scientific American

Does Your Utility Worry About:

- **Flat or declining kWh sales?**
  - **Fitch Ratings**: The expected small increases in U.S. electricity usage will add to the financial pressure on some power entities. The Energy Information Administration projects a 0.6 percent increase in consumption for industry and 0.7 percent for residences through 2040. Consumption fell in 2008, 2009, and 2011 with a small increase in 2010.

    Over the next three to five years, "we expect increasing challenges to the monopolistic utility business model as federal lighting standards will be fully effective in 2015" and competition introduced from energy efficiency and demand-response businesses "will hurt the utility credit profile,"

If Your Utility is Concerned About Flat or Declining kWh Sales:

- Solar PV spins the meter – backwards!
- Traditional efficiency programs also cut kWh usage
- Fuel switching – to natural gas – kills winter (off peak) space conditioning revenue but leaves the summer peak
- HVAC rebates based on SEER will not save the day (but they will make things worse!)

So What is HVAC Efficiency?

<u>Air Source</u>

~~ up to 19 SEER ??

~~ up to 20 SEER ??

~~ over 20 SEER ??

<u>Ground Source - Geothermal</u>

~~ up to 27 EER ??

~~ up to 30 EER ??

~~ 40 + EER ??

Air Conditioning Efficiency Ratings

Seasonal Energy Efficiency Ratio (SEER)

Energy Efficiency Ratio (EER)

- SEER – the total cooling output provided by the unit during its normal annual usage period divided by its total energy input during the same period.

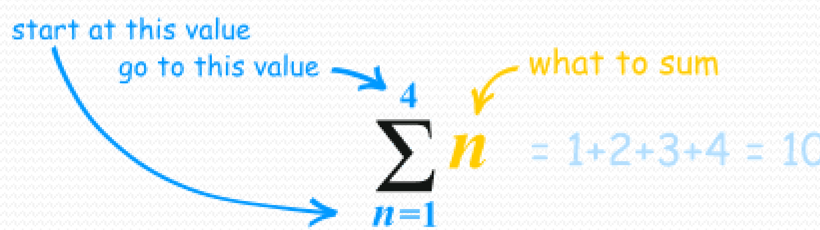
- EER for Air Source Systems – Efficiency/Capacity at 95 degree Out Door Temperature

- EER for GSHP's – Efficiency/Capacity determined by entering water temperature.

SEER IS NOT EER!

HVAC Efficiency "Measurements"

- There are two versions of SEER
  - True SEER – $\frac{\text{Total seasonal cooling output kBtu}}{\text{Total seasonal electric input kWh}}$



  - Government / "Industry" SEER
    - SEER became the mandatory federal efficiency metric for residential air conditioners in the late 1980s and for small commercial air conditioners in the early 1990s

Air Conditioning Refrigeration Institute "ARI"

ARI – Tests all A/C Equipment for SEER/EER

- The "calculations" for SEER require 136 pages in ANSI/AHRI STANDARD 210/240-2008 WITH ADDENDUM 2
- This is a formula based on lab measurements at 80 degrees inside and 82 & 95 outside (under perfect conditions)
- SEER can now be based/labeled on low speed operation!

HVAC Efficiency "Measurements"

- The major flaws in AHRI SEER ratings for air source heat pumps include:
  - Testing at -indoor air temp – 80 deg. / outdoor air 82 deg.
  - For variable capacity heat pumps, 66% of the rating (test) points are at 67, 72, and 77 deg. Outdoor air temps!
    - So the outdoor air is colder than the indoor air…for cooling!
  - Equipment can be rated with out dehumidification capacity – do you live in Las Vegas??????
  - There is no requirement to rate (or report) performance at outdoor air temps above 95 deg. (or below 17 deg for heating) much less at 105 +!

EER = Point in Time Efficiency

Energy Efficiency Ratio (EER)

EER = Btu capacity/system watts

<u>Example – 3 ton unit</u>

36000 Btu/10 EER = 3600 watts
36000 Btu/15 EER = 2400 watts

15 EER is 33% more efficient than 10 EER for the same Btu delivery

Efficiency Comparison

SEER is never equal to EER

3 Ton Single Speed Air Source Systems

13 SEER -- 11 EER

14 SEER -- 12 EER

15 SEER -- 13 EER

2-Speed High SEER Air Source Systems

2 ton - 19 SEER -- 14 EER

3 ton - 18.6 SEER -- 13 EER

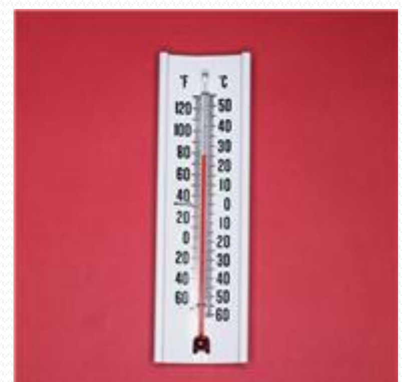
4 ton - 17.5 SEER -- 12 EER

5 ton - 17 SEER -- 11 EER

Ground Source HP's -- 16-21 EER

HVAC Efficiency "Measurements"

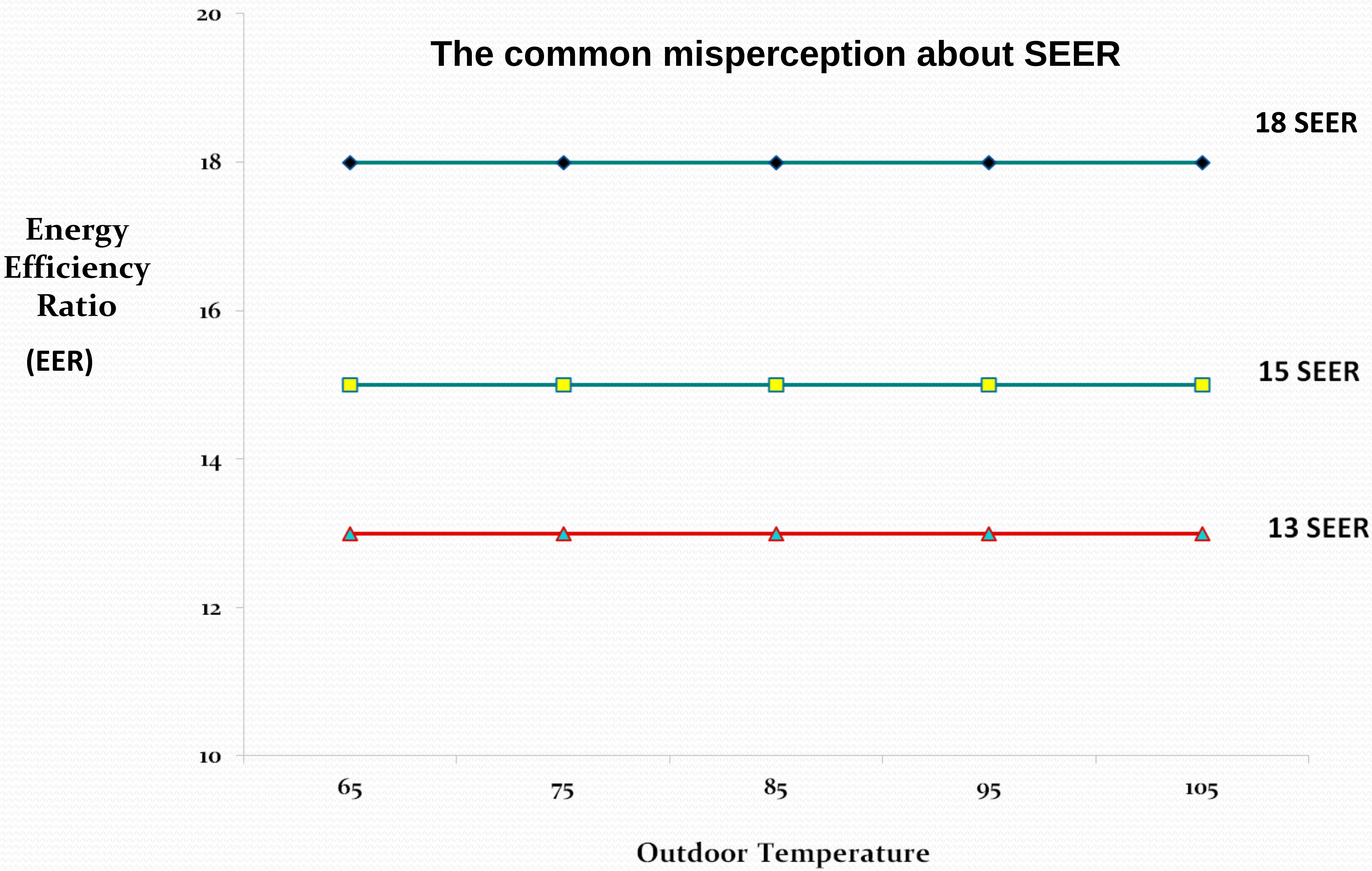
- How many of your customers set their indoor temperature at 80 degrees in the summer?
- How often does your system peak when it is :
  - 82 degrees outside?
  - 95 degrees outside?
  - 100 (or more) outside?



HVAC Efficiency "Measurements"

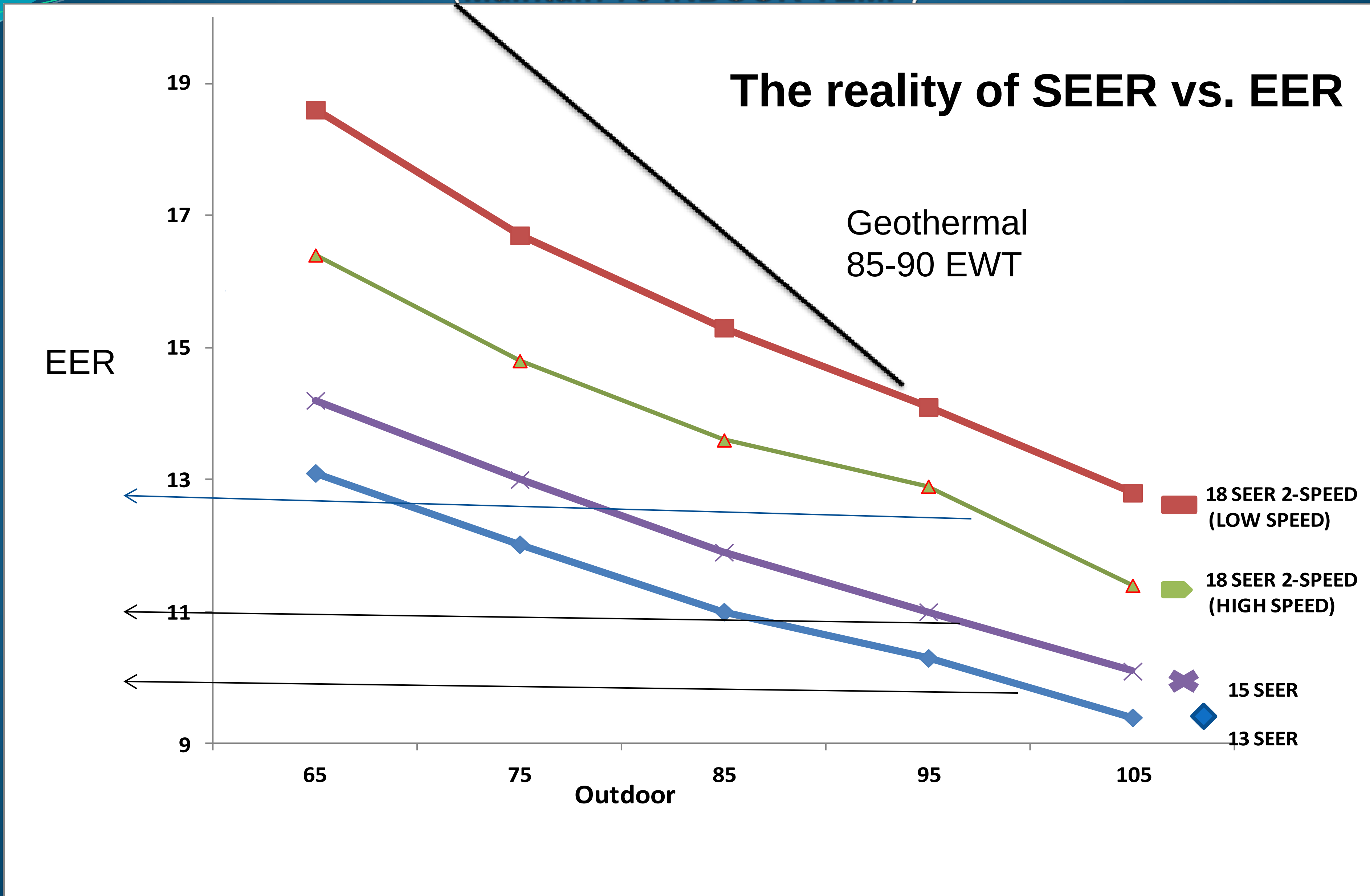
- What are the chances that the air conditioning equipment will be running on low speed on the hottest days of the year?
- If you were designing equipment and knew that 2 laboratory measurement conditions drove your efficiency rating, would you game the system to your advantage?

Air Source Efficiency

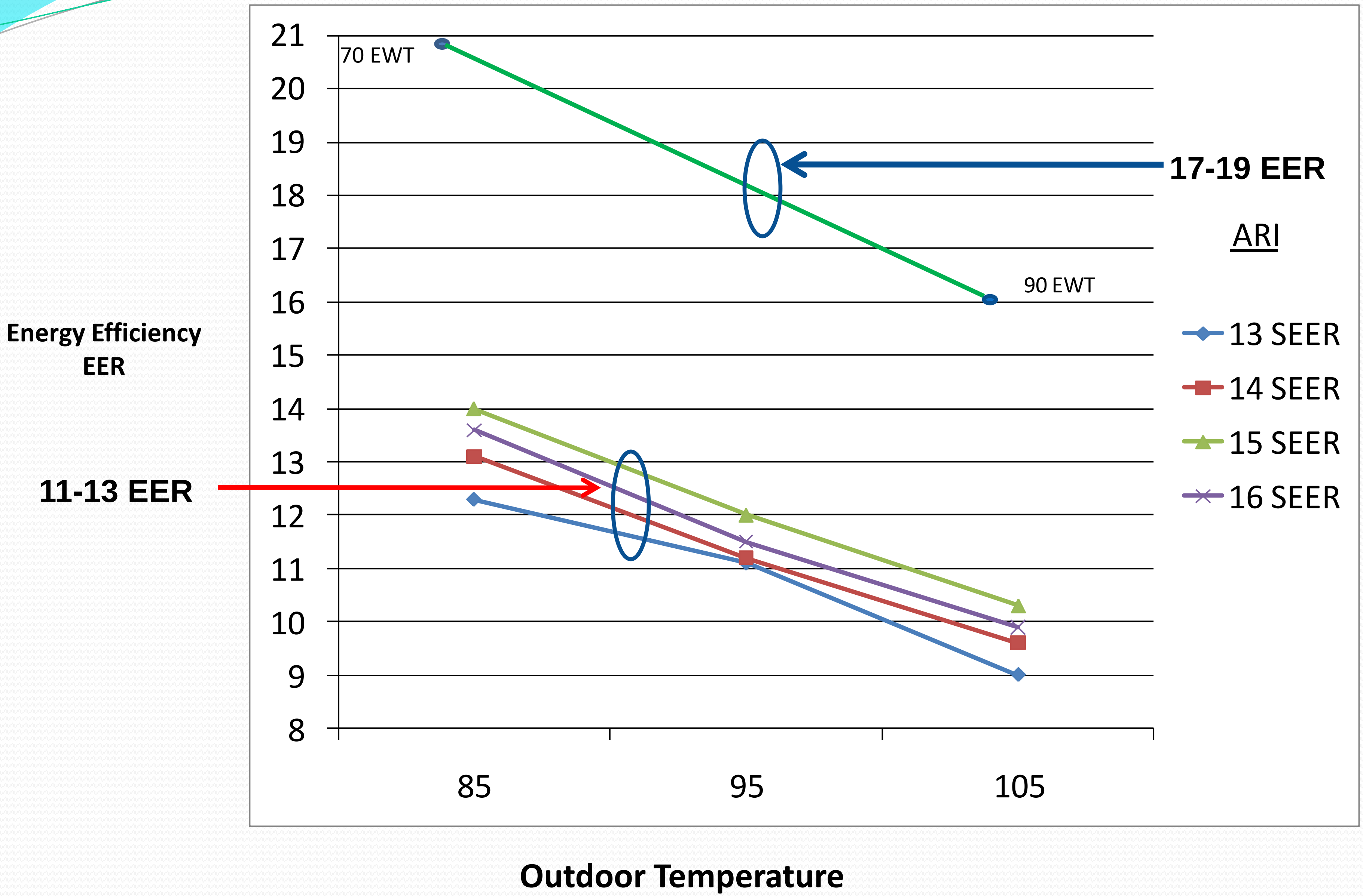


Air Source Efficiency

(Maintain 75 INDOOR TEMP)



Air Source to Ground Source Efficiency



The Reality of SEER

DETAILED COOLING CAPACITIES CONTINUED

EVAPORATOR AIR		CONDENSER ENTERING AIR TEMPERATURES DEG F																	
		75			85			95			105			115			125		
CFM	EWB	CAPACITY MBTUH†		TOTAL SYS-TEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYS-TEM KW**
		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡	
25HNA948A30 Outdoor Section With FE5ANB006 Indoor Section – Low Stage																			
950	72	41.05	20.59	1.94	39.20	20.17	2.19	37.19	19.69	2.46	35.01	19.12	2.78	32.64	18.47	3.14	31.55	18.30	3.11
	67	37.04	25.08	1.94	35.34	24.72	2.20	33.49	24.28	2.48	31.50	23.77	2.80	29.33	23.18	3.17	26.94	22.47	3.60
	††63	34.15	24.15	1.95	32.55	23.77	2.21	30.83	23.32	2.49	28.97	22.80	2.82	26.95	22.19	3.19	24.72	21.48	3.63
	62	33.38	29.56	1.95	31.81	29.25	2.21	30.13	28.86	2.50	28.34	28.37	2.82	26.64	26.64	3.20	24.89	24.89	3.62
	57	32.14	32.14	1.95	30.94	30.94	2.21	29.63	29.63	2.50	28.20	28.20	2.82	26.64	26.64	3.20	24.89	24.89	3.62
1120	72	42.27	21.90	1.98	40.32	21.49	2.23	38.18	21.00	2.50	35.87	20.43	2.81	35.07	20.41	2.75	30.64	19.02	3.59
	67	38.17	27.18	1.98	36.35	26.83	2.24	34.40	26.40	2.51	32.29	25.90	2.83	30.00	25.30	3.20	27.50	24.60	3.63
	††63	35.22	26.13	1.99	33.52	25.76	2.24	31.69	25.31	2.53	29.72	24.79	2.85	27.59	24.18	3.23	25.26	23.46	3.66
	62	34.48	32.42	1.99	32.85	32.55	2.25	31.31	31.31	2.53	29.75	29.75	2.85	28.05	28.05	3.22	26.15	26.15	3.64
	57	34.05	34.05	1.99	32.73	32.73	2.25	31.31	31.31	2.53	29.75	29.75	2.85	28.05	28.05	3.22	26.15	26.15	3.64
1300	72	43.15	23.16	2.04	41.12	22.76	2.28	38.88	22.27	2.56	36.46	21.69	2.87	33.86	21.05	3.22	32.81	20.94	3.20
	67	38.99	29.26	2.04	37.09	28.91	2.29	35.04	28.50	2.57	32.84	28.00	2.89	30.46	27.40	3.25	27.83	26.67	3.67
	††63	36.00	28.08	2.05	34.21	27.71	2.30	32.30	27.28	2.58	30.25	26.76	2.91	28.04	26.14	3.28	25.57	25.36	3.70
	62	35.66	35.66	2.05	34.24	34.24	2.30	32.70	32.70	2.58	31.04	31.04	2.90	29.20	29.20	3.27	27.16	27.16	3.69
	57	35.66	35.66	2.05	34.24	34.24	2.30	32.70	32.70	2.58	31.04	31.04	2.90	29.20	29.20	3.27	27.16	27.16	3.69

EVAPORATOR AIR		CONDENSER ENTERING AIR TEMPERATURES DEG F																	
		75			85			95			105			115			125		
CFM	EWB	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYS-TEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**	CAPACITY MBTUH†		TOTAL SYSTEM KW**
		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡		TOTAL	SENS‡	
25HNA948A30 Outdoor Section With FE4ANB006 Indoor Section – High Stage																			
1200	72	55.51	28.17	3.04	52.87	26.88	3.33	50.04	25.54	3.64	47.04	24.17	3.99	43.82	22.74	4.36	42.03	21.87	4.35
	67	50.45	34.17	2.99	48.01	32.78	3.28	45.43	31.35	3.59	42.68	29.88	3.93	41.17	28.96	3.84	36.51	26.78	4.71
	††63	46.77	33.06	2.95	44.49	31.67	3.24	42.07	30.26	3.54	39.50	28.81	3.88	36.75	27.30	4.25	33.75	25.73	4.66
	62	45.78	40.15	2.94	43.55	38.66	3.23	41.19	37.14	3.53	38.68	35.56	3.87	36.00	33.92	4.24	34.27	33.95	4.21
	57	43.40	43.40	2.91	41.65	41.65	3.21	39.77	39.77	3.52	37.76	37.76	3.86	35.59	35.59	4.24	34.14	34.14	4.21
1400	72	56.95	29.64	3.14	54.18	28.31	3.43	51.18	26.93	3.74	48.03	25.51	4.08	44.65	24.05	4.45	42.85	23.17	4.45
	67	51.80	36.59	3.08	49.23	35.14	3.37	46.50	33.65	3.68	43.61	32.13	4.02	42.07	31.18	3.93	37.14	28.90	4.80
	††63	48.05	35.34	3.04	45.64	33.90	3.33	43.09	32.43	3.64	40.39	30.92	3.97	37.50	29.36	4.34	35.65	28.27	4.31
	62	47.08	43.49	3.03	44.73	41.91	3.32	42.26	40.28	3.63	39.69	39.37	3.97	37.22	37.22	4.34	35.71	35.71	4.31
	57	45.65	45.65	3.02	43.75	43.75	3.31	41.73	41.73	3.62	39.56	39.56	3.96	37.22	37.22	4.34	35.71	35.71	4.31
1600	72	57.92	30.94	3.26	55.01	29.57	3.54	51.93	28.16	3.85	48.66	26.71	4.19	45.15	25.21	4.57	43.36	24.34	4.56
	67	52.72	38.81	3.20	50.04	37.31	3.48	47.19	35.78	3.79	44.18	34.20	4.13	40.97	32.57	4.50	37.49	30.86	4.91
	††63	48.92	37.42	3.16	46.41	35.93	3.44	43.75	34.41	3.75	40.95	32.85	4.08	37.95	31.24	4.45	36.07	30.11	4.42
	62	48.03	46.51	3.15	45.62	44.78	3.43	43.25	43.25	3.74	40.95	40.95	4.09	39.64	39.64	4.00	35.73	35.73	4.88
	57	47.44	47.44	3.14	45.40	45.40	3.43	43.25	43.25	3.74	40.95	40.95	4.09	39.65	39.65	4.00	35.74	35.74	4.88

EER Test Data for a Heat Pump Unit Promoted at 19 SEER

Outdoor air temp

75		
CAPACITY MBTUH†		TOTAL SYS-TEM KW**
TOTAL	SENS‡	
41.05	20.59	1.94
37.04	25.08	1.94
34.15	24.15	1.95
33.38	29.56	1.95
32.14	32.14	1.95
42.27	21.90	1.98
38.17	27.18	1.98
35.22	26.13	1.99
34.48	32.42	1.99
34.05	34.05	1.99
43.15	23.16	2.04
38.99	29.26	2.04
36.00	28.08	2.05

At 115 degrees EER drops to 8.5

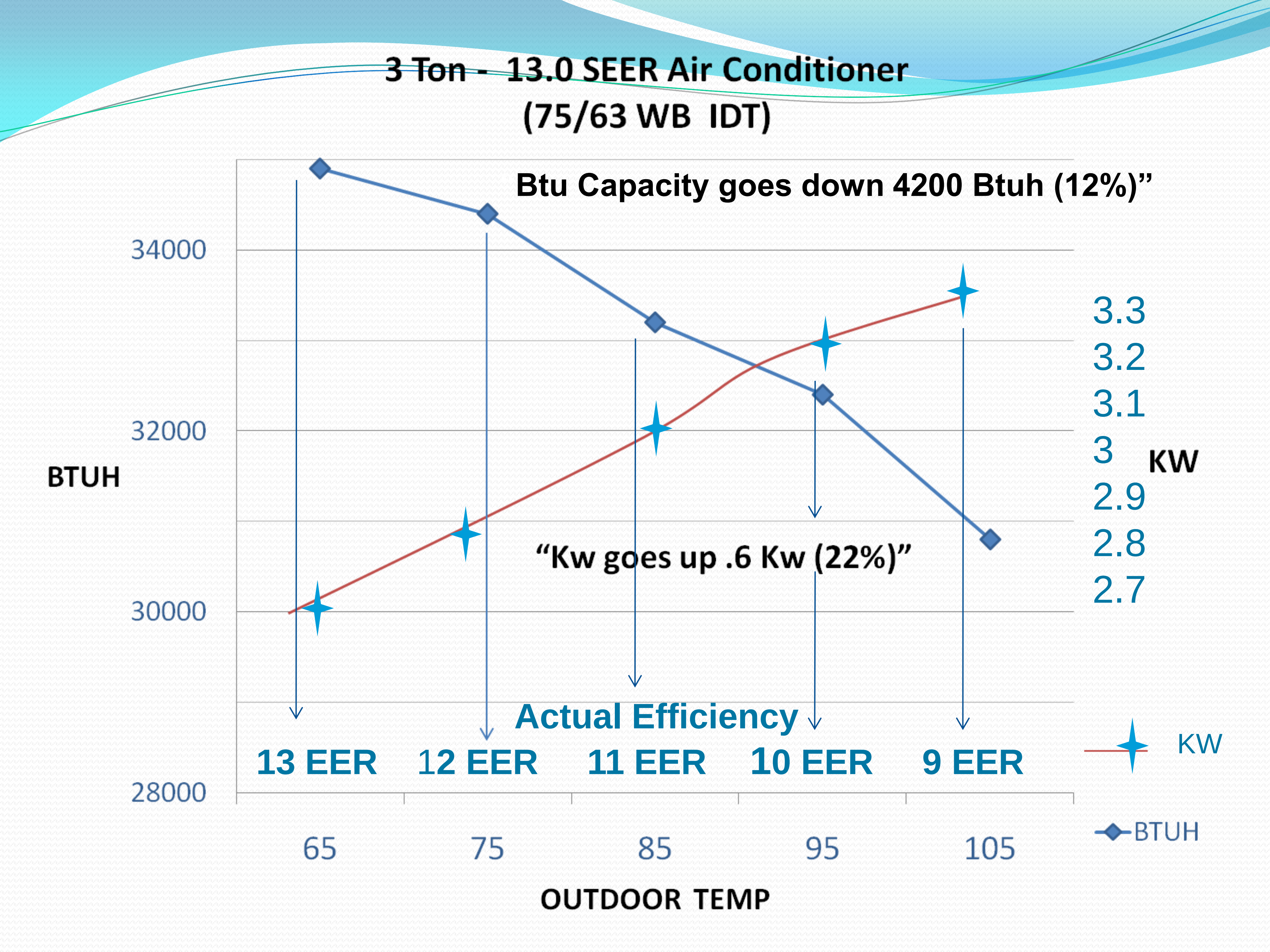
36/2.05 = 17.5 EER

30.25/2.91 = 10.3 EER

105		
CAPACITY MBTUH†		TOTAL SYSTEM KW**
TOTAL	SENS‡	
oor Section – Low Stage		
35.01	19.12	2.78
31.50	23.77	2.80
28.97	22.80	2.82
28.34	28.37	2.82
28.20	28.20	2.82
35.87	20.43	2.81
32.29	25.90	2.83
29.72	24.79	2.85
29.75	29.75	2.85
29.75	29.75	2.85
36.46	21.69	2.87
32.84	28.00	2.89
30.25	26.76	2.91

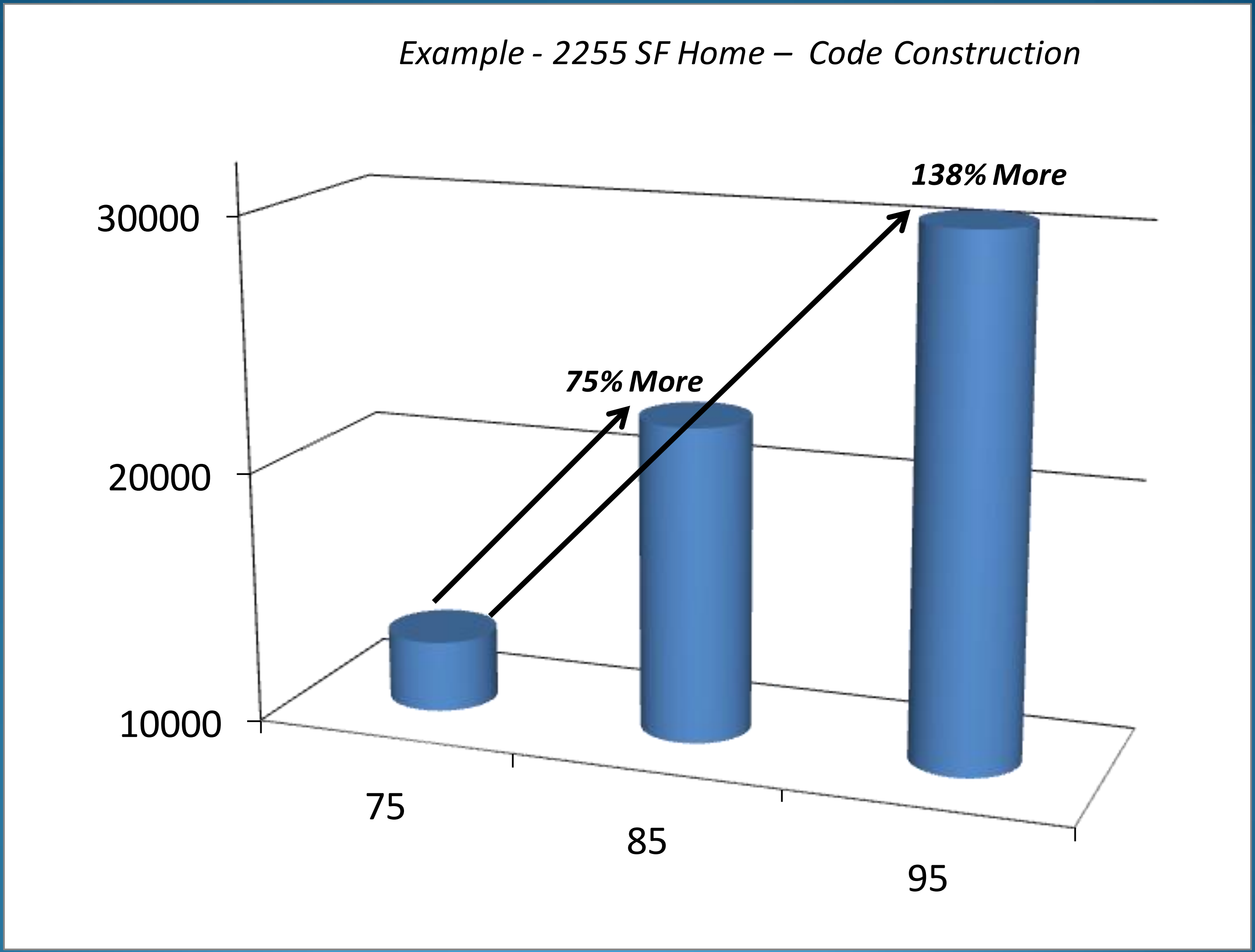
Something Else You May Not Know

- As the outdoor Temperature rises, the capacity of air source equipment drops – a refrigerant function
  - But -to keep occupants comfortable, the equipment (capacity) needs to be sized to match the peak load…. so systems are oversized off-peak
- Outside air coils deteriorate in performance over time and (field installed) refrigerant charges are critical to performance
- “Field conditions” never match “laboratory conditions” and have little chance of being better



3 Ton - 13.0 SEER Air Conditioner
(75/63 WB IDT)
Btu Capacity goes down 4200 Btuh (12%)”
34000
32000
30000
28000
BTUH
3.3
3.2
3.1
3
KW
2.9
2.8
2.7
“Kw goes up .6 Kw (22%)”
Actual Efficiency
13 EER
12 EER
11 EER
10 EER
9 EER
KW
BTUH
65
75
85
95
105
OUTDOOR TEMP

Outdoor Ambient Temperature Effect on Home Btuh Requirements



Btuh Heat removal to maintain 75 indoors

Outdoor Temperature

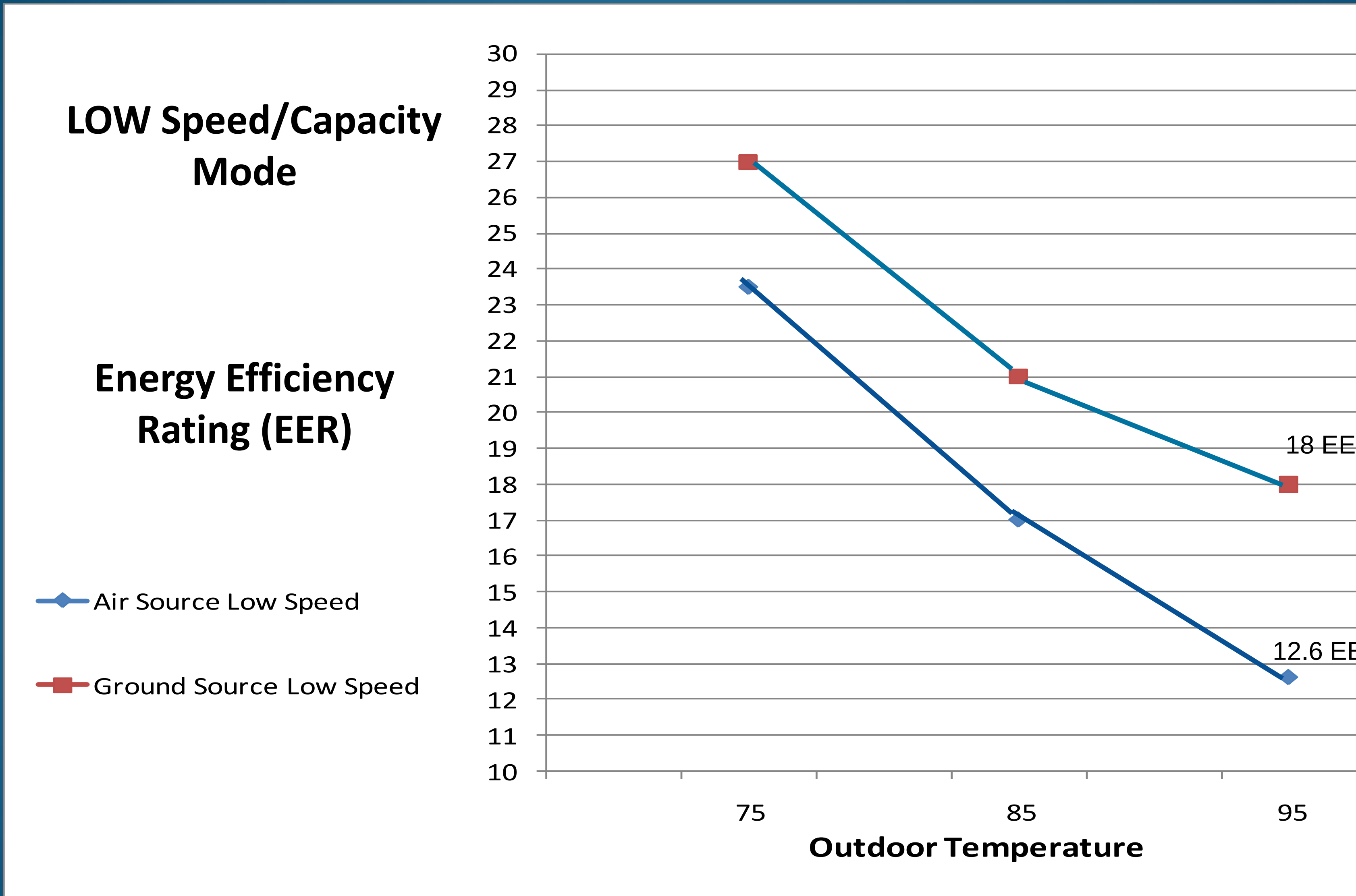
"The best efficiency is when the A/C unit runs the least!"

HP-A/C Efficiency Analysis

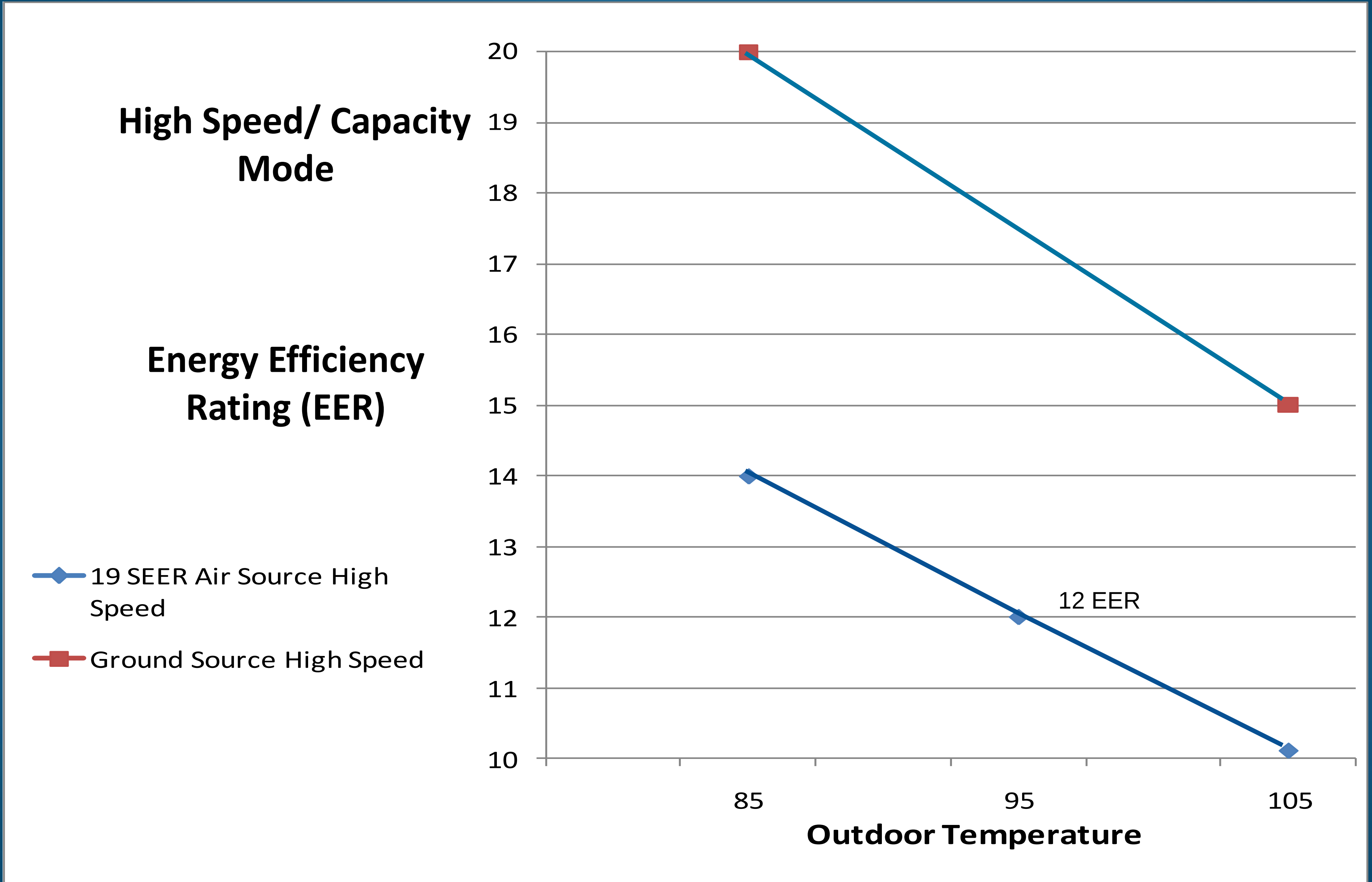
High SEER Air Source Units

SEER – 2--Speed Compressors

Best Air Source vs. Ground Source Efficiency



Best Air Source vs. Best Ground Source Efficiency



Summary -Air Source vs. Ground Source Efficiency

At Typical Summer Outdoor Temps – 85-95 degrees:

The SEER Rating Efficiency is realized at very low outdoor ambient temps (~75 degrees) -- when there are less run operating hours

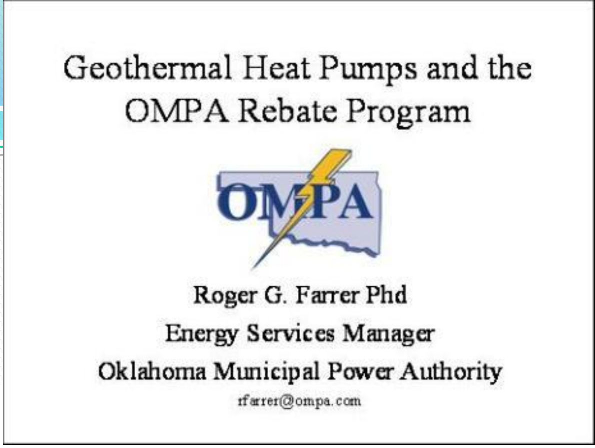
Residential 2-Speed System Efficiency

- **Ground Source Exceeds Air Source Efficiency – 26% for high speed A/C operation**
- **Ground Source Exceeds Air Source Efficiency – 33% on low speed A/C operation**

Single-Speed System Efficiency

- **Ground Source Exceeds Air Source 13 SEER Unit Efficiency – 40% on A/C Operation**

Demand Impacts



GHP Summary

kW/ton at 85 F Outside Air Temperature

EER	GHP #1	GHP #2	GHP #3	Average	*Difference vs 13 SEER AC
15.1	0.89	0.84	0.83	0.85	0.45
16	0.85	0.81	0.81	0.82	0.48
17	0.80	0.77	0.78	0.78	0.52

GHP Value
.5 kW/ton

*Assumes 13 SEER AC at 105° F outside air temperature is about 1.3 kW/ton
GHP EER of 15.1 is our minimum standard for rebate

Demand Impacts

- Western Farmers initial rebate effort relied on EER for ground source and SEER for air source.
- After evaluating the results of their 2010 program they had to drastically modify their program if they hoped to achieve their peak reduction goal.

	ASHP	GSHP
Projected kW reduction per ton rebated	0.33 kW	0.66 kW
2010 results kW reduction/ton rebated	0.16 kW	0.65 kW

Demand Impacts

- In several cases the ROI on air source installations exceeded the expected life expectancy of the air source equipment
- In many cases the new (rebated) air source equipment had decreased energy sales without reducing peak capacity requirements

Demand Impacts

- After evaluating the results of their 2010 program they had to drastically modify their program if they hoped to achieve their peak reduction goal.
- Now require air source equipment to meet high EER ratings at 95 degrees.
- Moved most of their rebate money from air source to ground source
- Are working with CRN on a major study to compare actual before and after peak demand performance this summer with 20+ in field retrofits – suspect the real savings is 1kW/ton+

National Peak Demand Impacts

- Each residential heat pump linked to geothermal system can reduce peak loads in (US DOE)
  - Summer by 1–2 KW vs. AC
  - Winter by 4–8 KW vs. AAHP & ER
- Residential Market Potential
  - Over 10 million residential consumers
  - Assume just 1 KW reduction per installation
  - 10,000 MW demand reduction
  - With increased kWh sales, reduced carbon emissions, and lower customer energy bills

HVAC Efficiency

What about Commercial?

Chillers

Roof-Top Units/Air Cooled HVAC

GSHP’s

Geothermal Efficiency Example

(Actual New Commercial Building – Closed~Loop – 116 Tons)

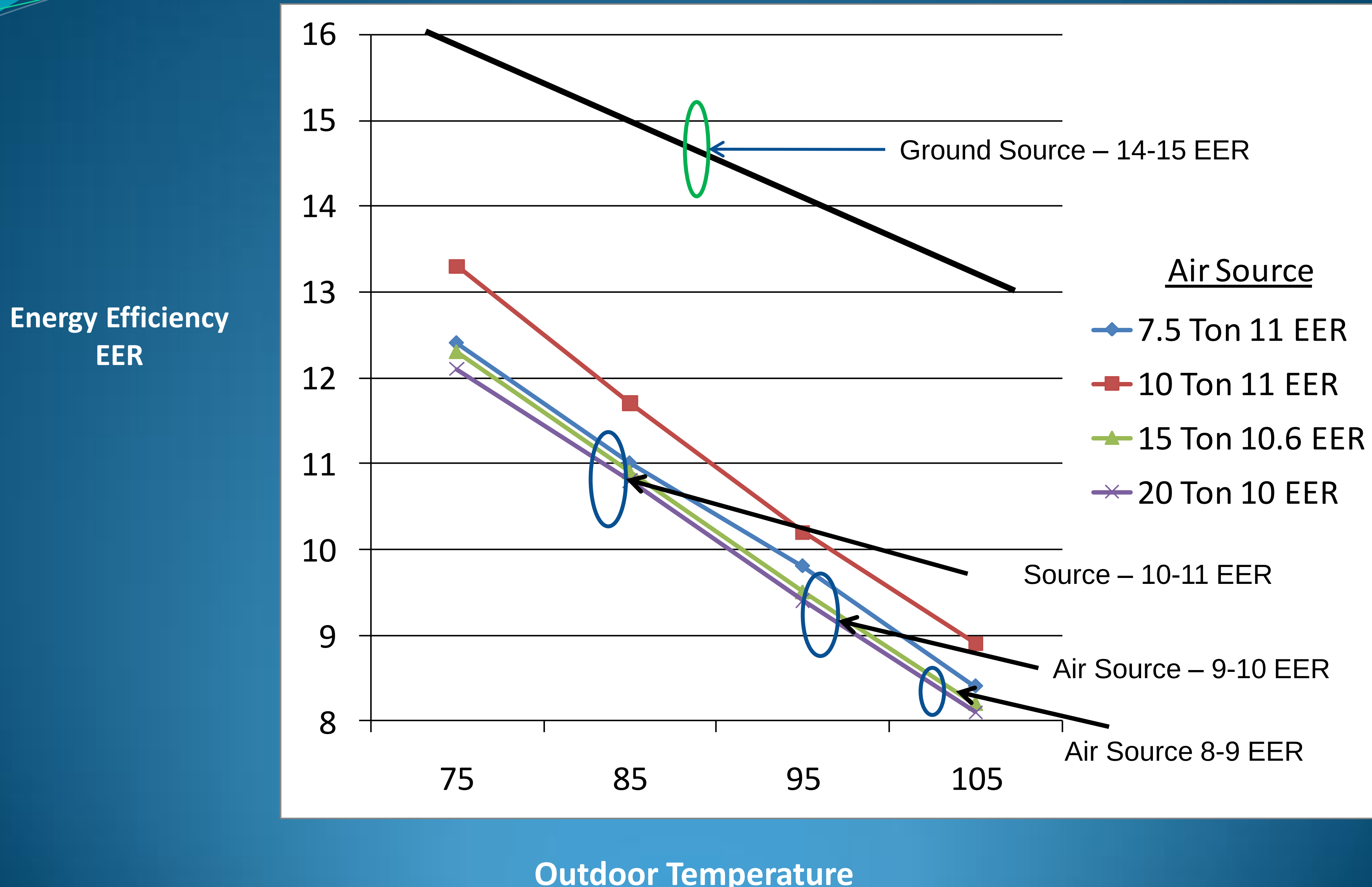
Ground Source Heat Pumps – 116 tons - 13.5 EER – 103 Kw

Adding the Auxiliary Components:
Circulation Pump -- 7.46 kW
Building Exhaust Fans -- .6 kW
Total Auxiliary -- 8.06 kW
Overall System Kw --- 8.06 + 103 = 111 kW

Overall GHP System Efficiency
116 tons x 12,000/111,000 watts = 12.5 EER

Same building with conventional boiler/chiller
120 tons x 12,000/275,000 watts = 5.2 EER

Commercial Air Source A/C vs. Ground Source Efficiency



Geothermal Efficiency Example

(Actual New Commercial Building – Closed Loop – 116 Tons)

Water Source Heat Pumps – 116 tons - 13.5 EER – 103 kW

Adding the Auxiliary Components:
Circulation Pump -- 7.46 kW

Overall System kW --- 7.46 + 103 = 110.46 kW

Overall System Efficiency
116 tons x 12,000/110,460 watts = **12.6 EER -- .95 kW/ton**

Chiller Efficiency Example

- Chiller VAV System - .5 kW/ton – 24 EER

- Adding the auxiliary components:
- Air Handler Fans
- Chilled Water Pump
- Condenser Pump
- Cooling Tower Fan
- Zone or VAV Fans

- Overall System Efficiency Result ------ 7-8 EER

Source: July 2003 ASHRAE Journal article "Estimating Demand and Efficiency", by Steve Kavanaugh.

Chiller Efficiency Example

(Actual New Commercial Building 120 Tons)

Air Cooled Chiller – (condenser fan & compressor) 9.3 EER -- 155 kW

Adding the Auxiliary Components:

Chilled Water Pump	-- 11 kW
AHU Motors	-- 61 kW
Total Auxiliary	-- 72 kW
Overall System kW	--- 72 + 155 = 227 kW

Overall Full Load System Efficiency

-- 120 tons x 12,000/227,000 watts = **6.3 EER -- 1.89 kW/ton**

Geothermal Efficiency Example

(Actual New Commercial Building – Closed Loop – 19 Tons)

Water Source Heat Pumps – (6 units) 15.5 EER – 14.7 kW

Adding the Auxiliary Components:

Circulation Pump -- 1.7 kW

Total Auxiliary -- 1.7 kW

Overall System kW --- 1.7 + 14.7 = 16.4 kW

Overall System Efficiency

19 tons x 12,000/16,400 watts = **13.9 EER -- .86 kW/ton**

“Conclusion” Commercial HVAC System Efficiency

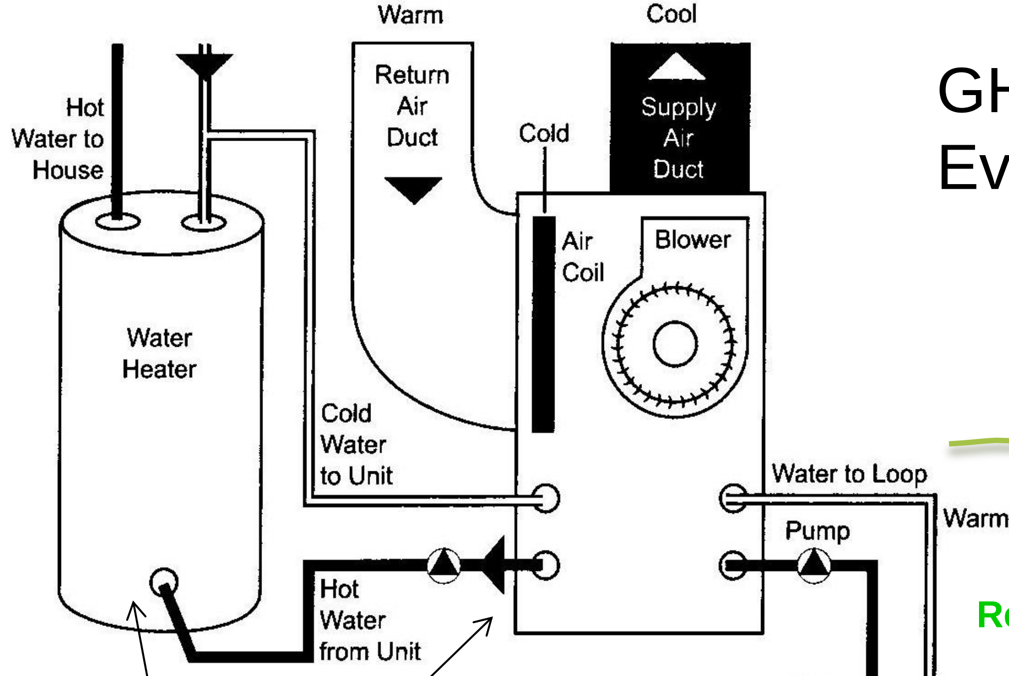
Chillers	1.8 kW/ton
Roof-Top Units	1.2 kW/ton
GSHP’s	.9 kW/ton

GSHP’s vs. Air Source System Efficiency

25% more efficient that packaged equipment

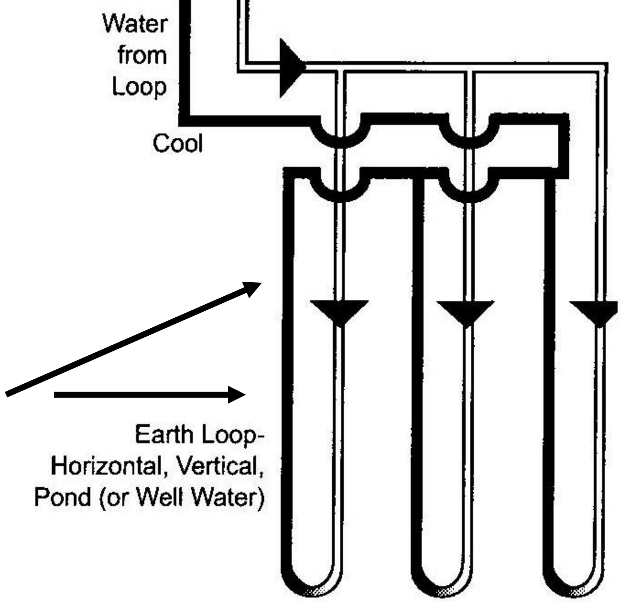
50% more efficient than air cooled chillers

Cooling Operation



GHP Designs are Evolving – FAST!

Heat transfer Refrigerant/Water/Ground

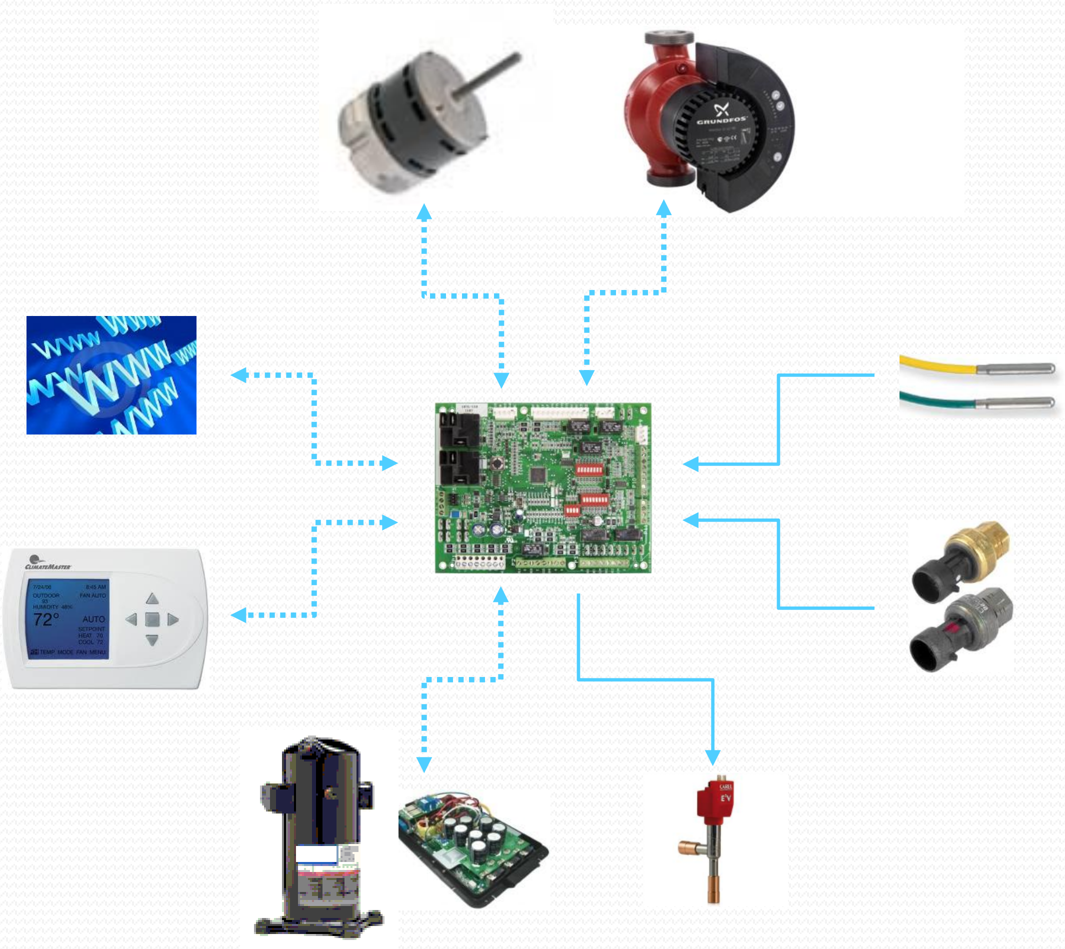


HRU -- 30- 50% FREE Hot Water!
50% reduction on demand (W-W)

Sustainable – Ground loop 50+ years

-- ground loop will serve multiple unit replacements

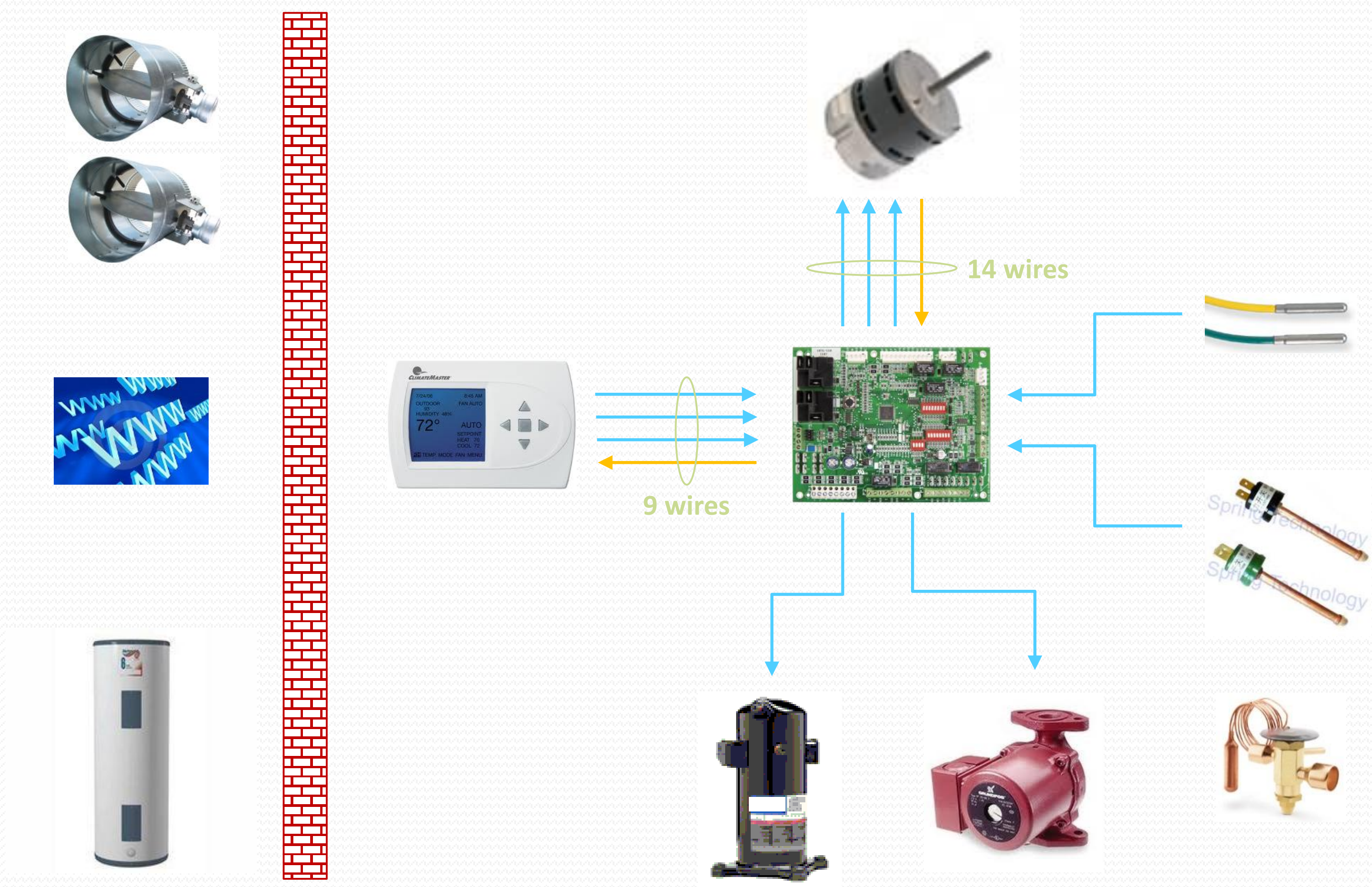
A GHP Technology Revolution is Underway



Advanced Controls

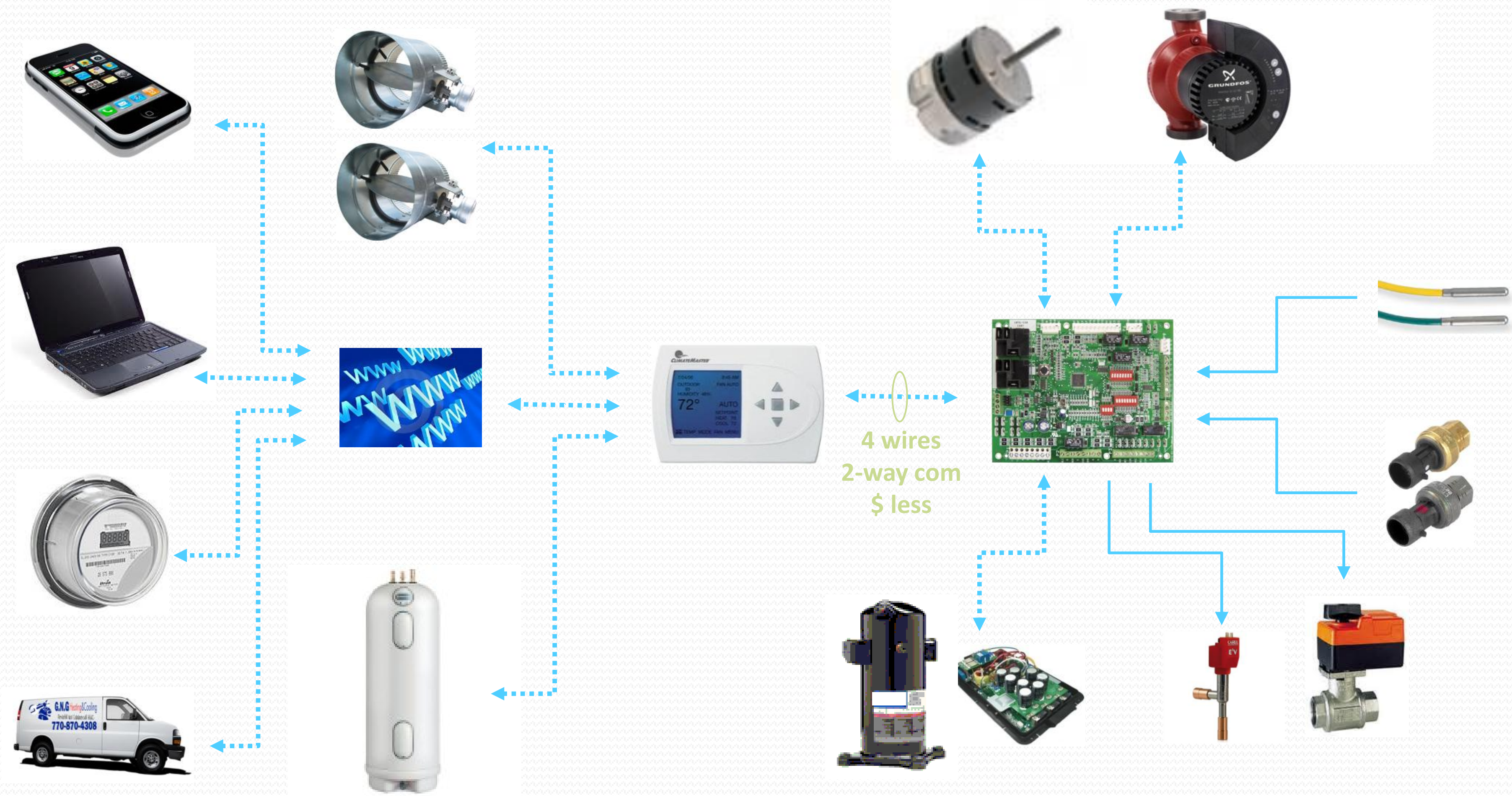
Current GHP Controls

Circa 1990



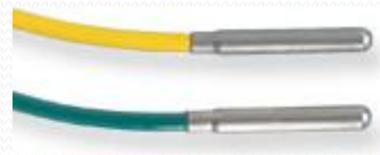
Communicating GHP Controls

Launched 2011



Smart Components

Smart Sensors



versus switch
$ less

new points
< $10

added cost
< $ 75

added cost
< $ 150

Smart Valves

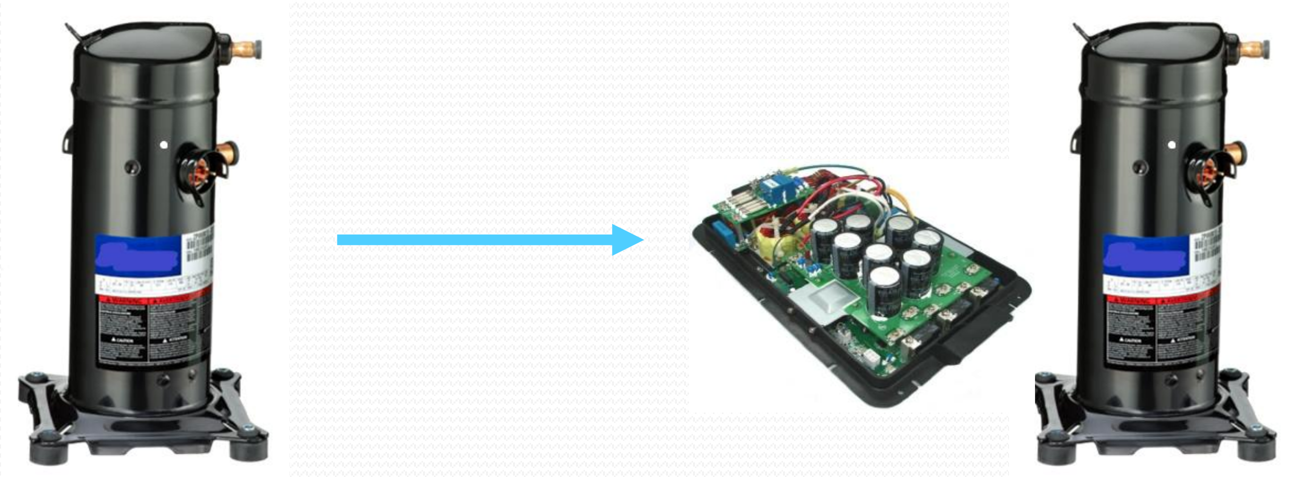
added cost
< $ 50

$ less

Variable Speed

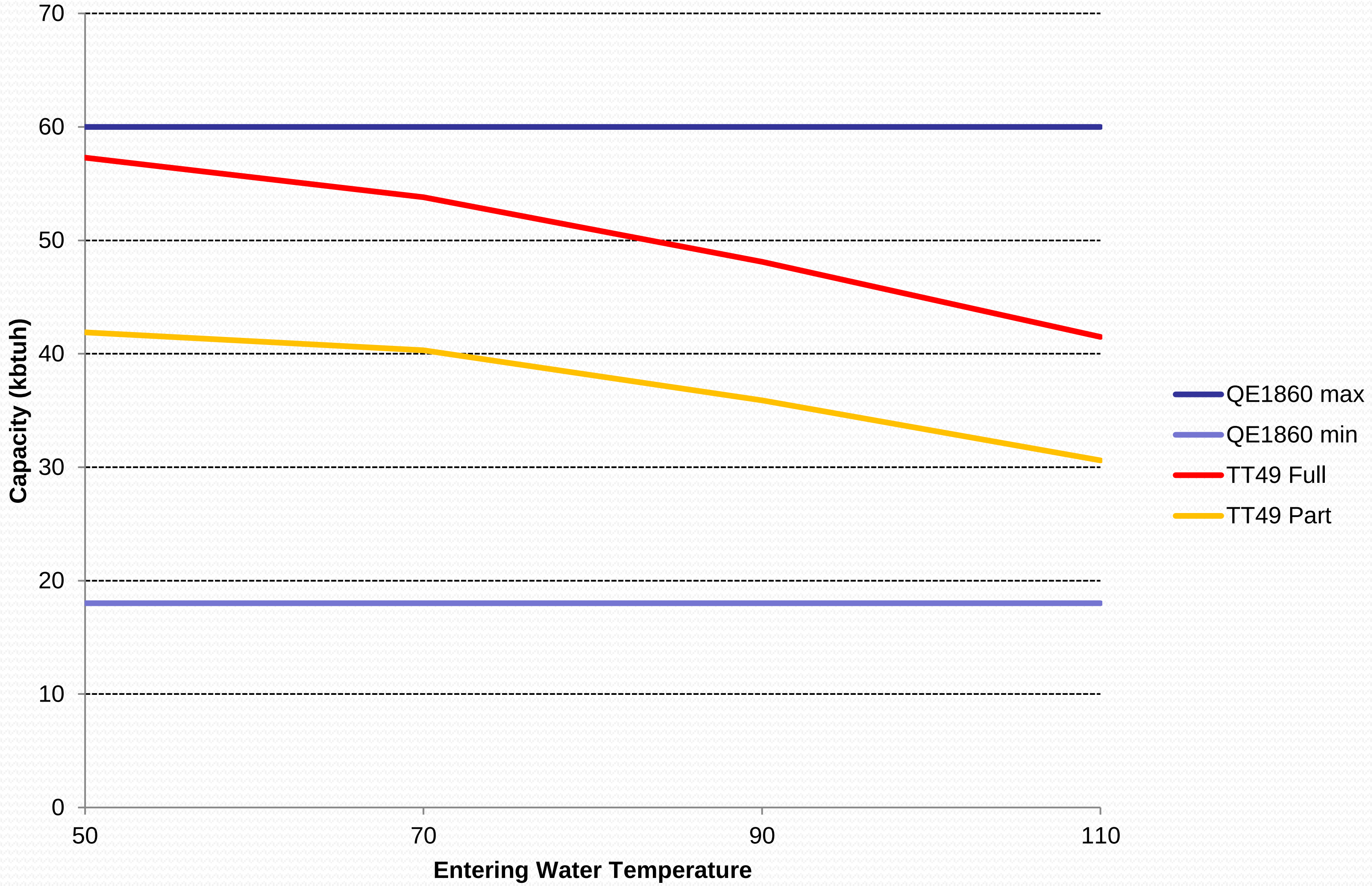
Variable Speed Compressor

Field Trials began in 2009



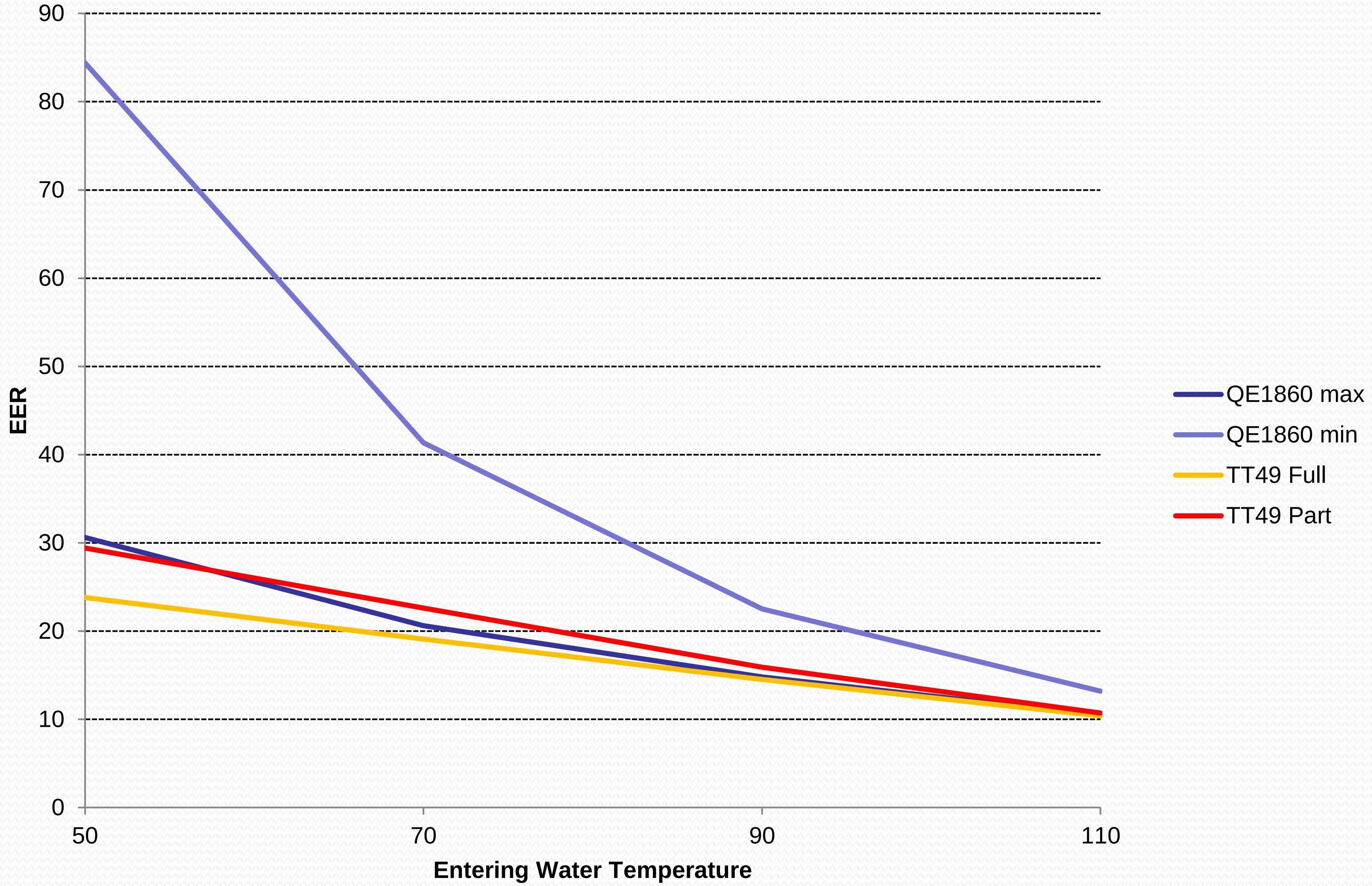
Trilogy QE1860 Capacity

Cooling Mode



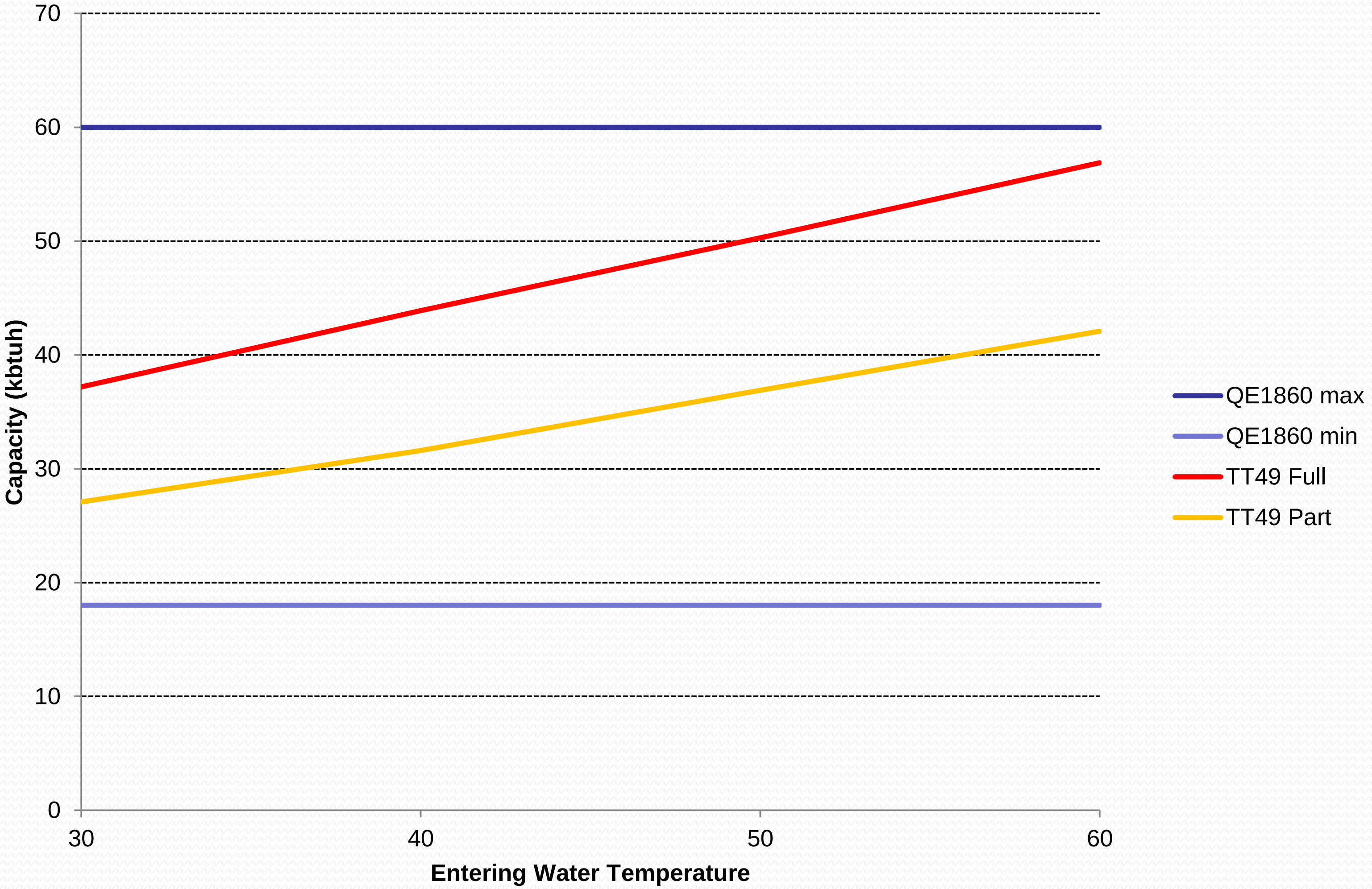
Trilogy QE1860 Efficiency

Cooling Mode



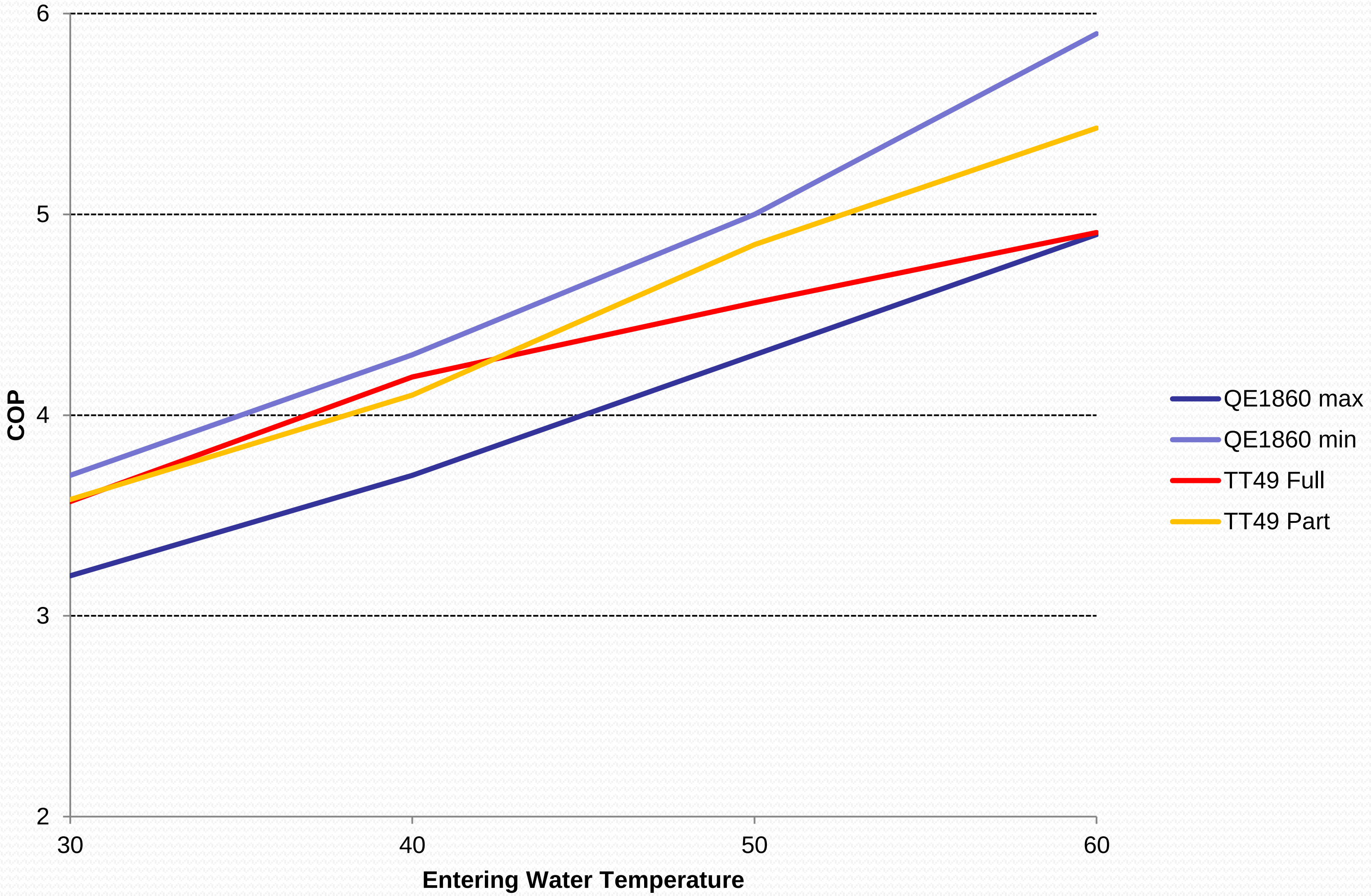
Trilogy QE1860 Capacity

Heating Mode



Trilogy QE1860 Efficiency

Heating Mode



Trilogy Series

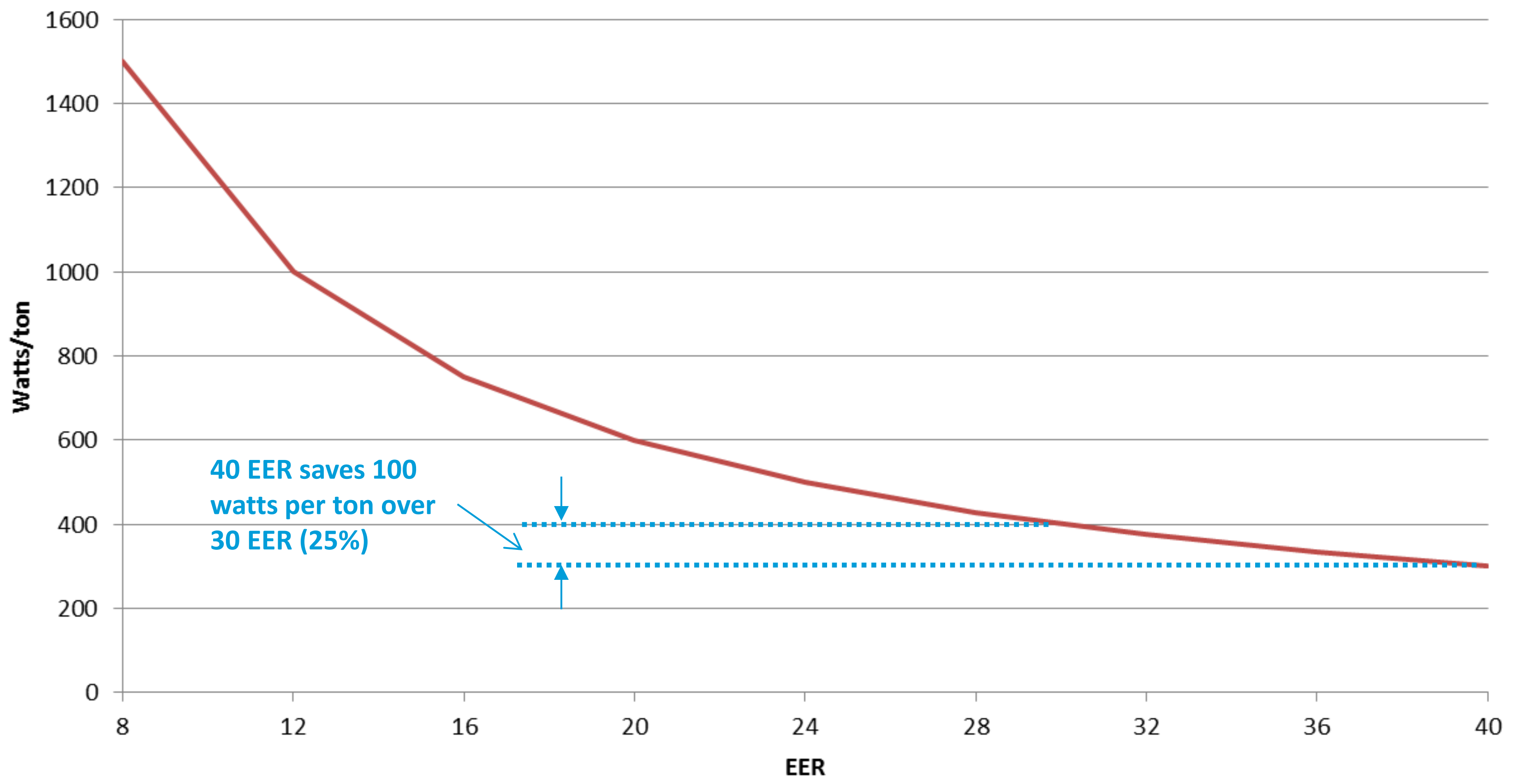
Benefits

- Comfort – Better Temperature, Humidity, and LAT Control
- Efficiency – Higher Part-Load Efficiencies and Lower Cycling Losses
- Wide Capacity Range – Better for Precise Zoning without Issues
- Over-speed Capability – Eliminates Resistance Heat and Meets Summer Extremes
- System Diagnostics – Full Implementation of Smart Components

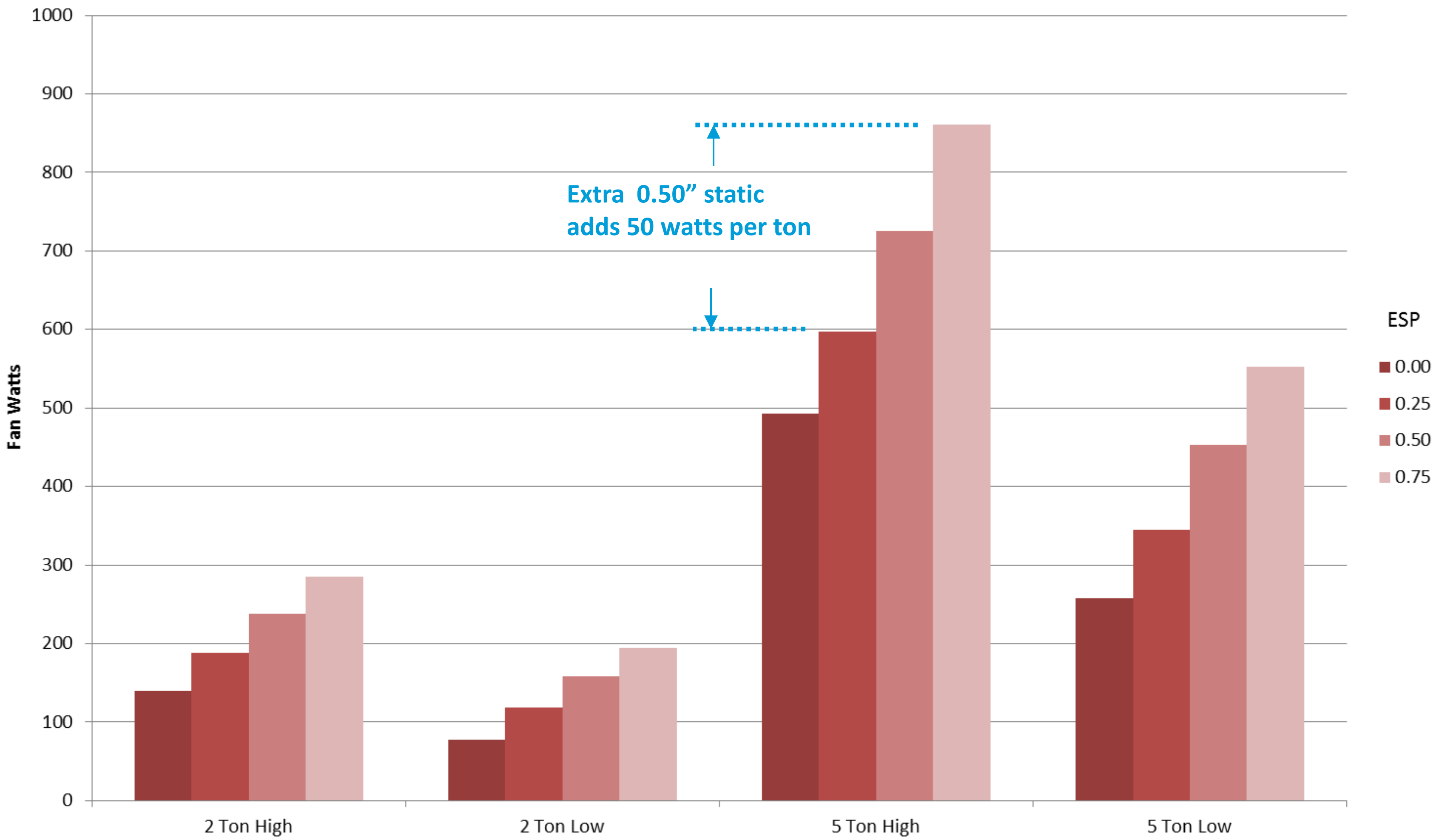
Drawbacks

- Higher First Cost
- Economics – Little Low Hanging Fruit with Current 2-stage GHPs (STL Cool < $300 yr)
- Desuperheater Capacity – Low Discharge Line Temperatures
- Complexity – Requires Better Trained Technicians

EER and Cooling Energy Consumption

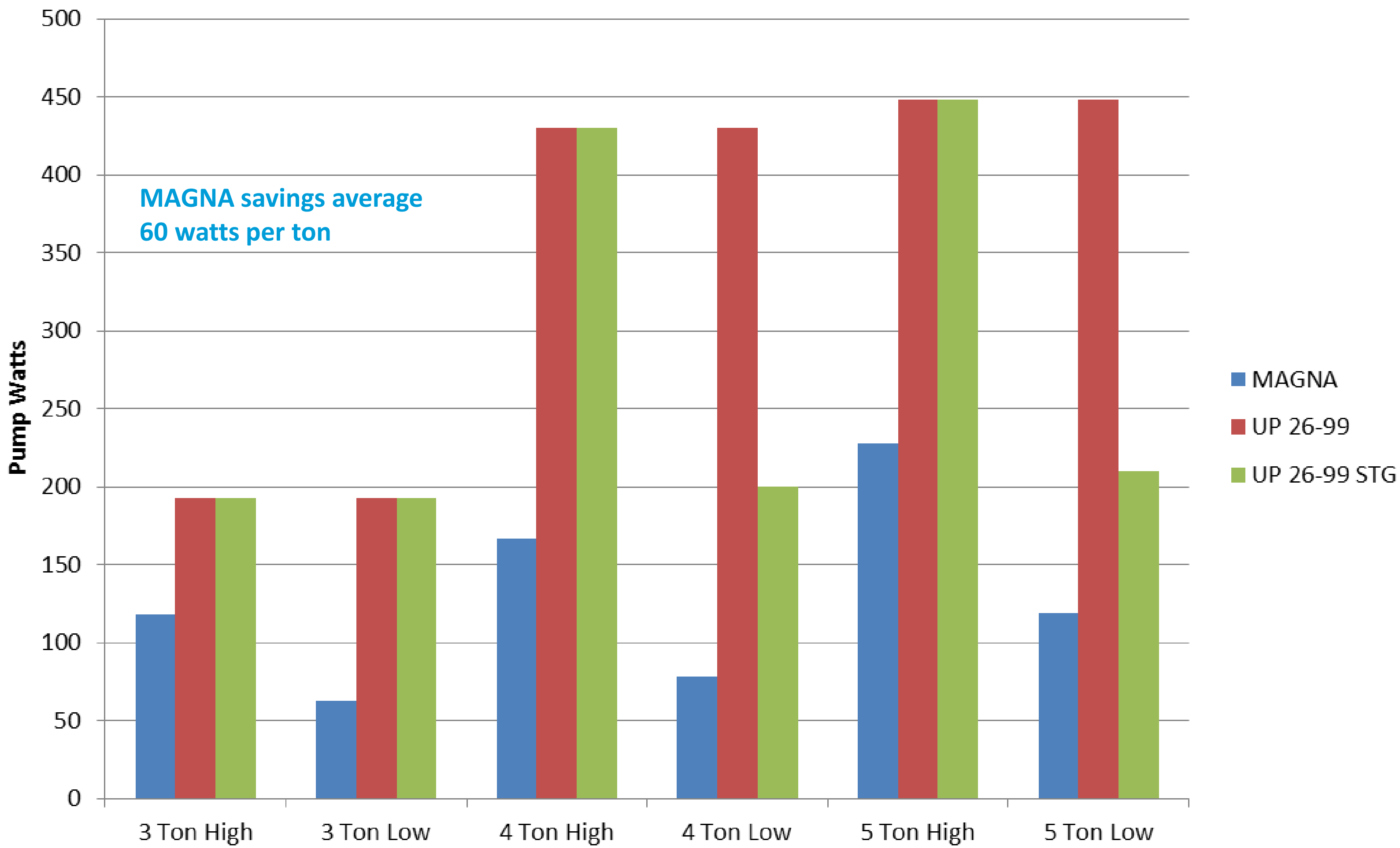


Fan Energy Consumption



Variable Speed Pump

Pump Energy Consumption

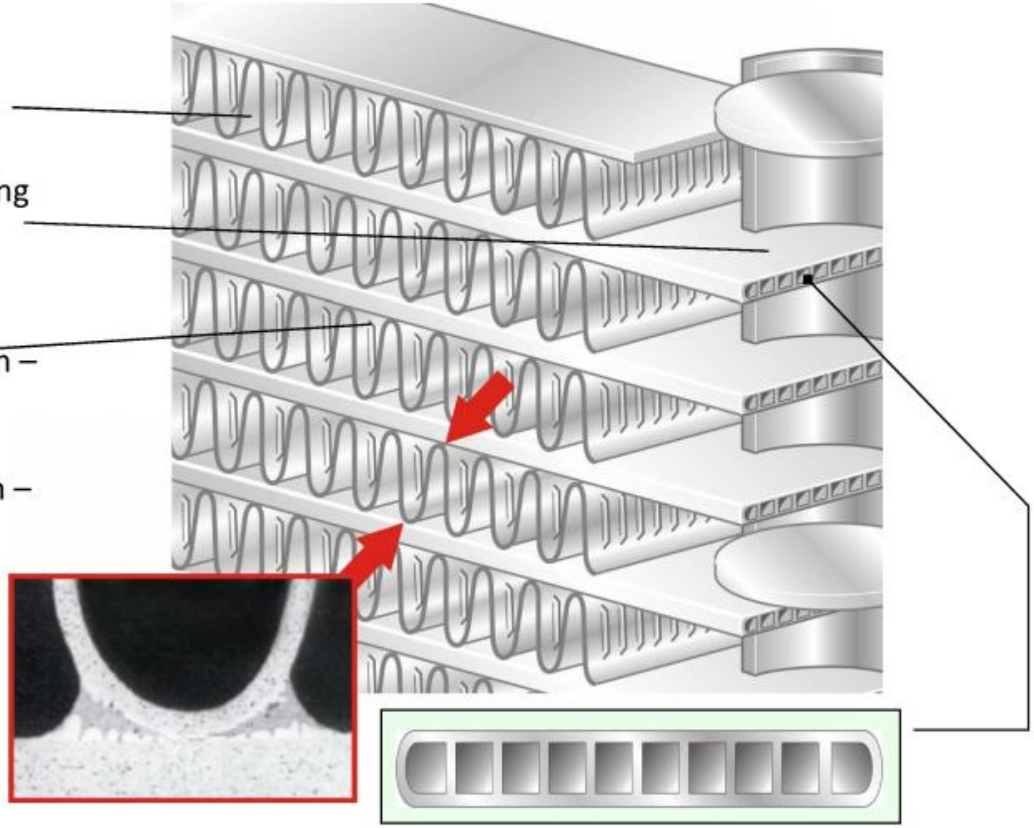


Advanced Heat Exchangers

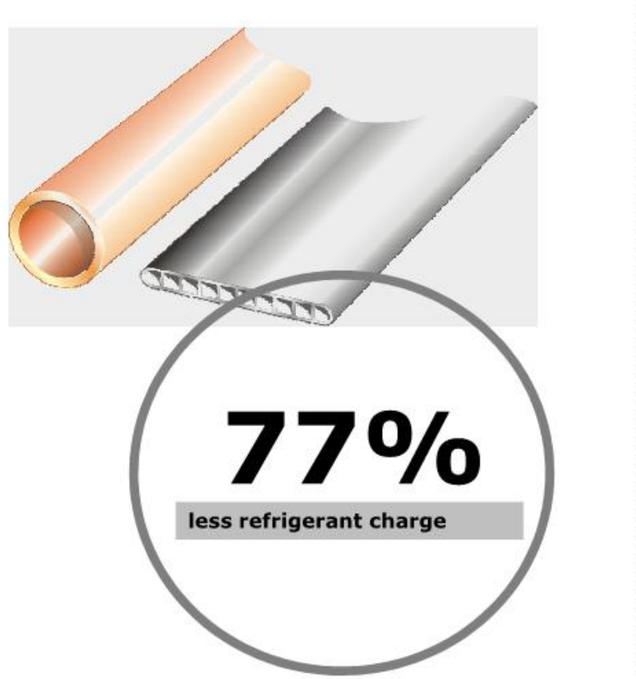
Micro-Channel Air Coils

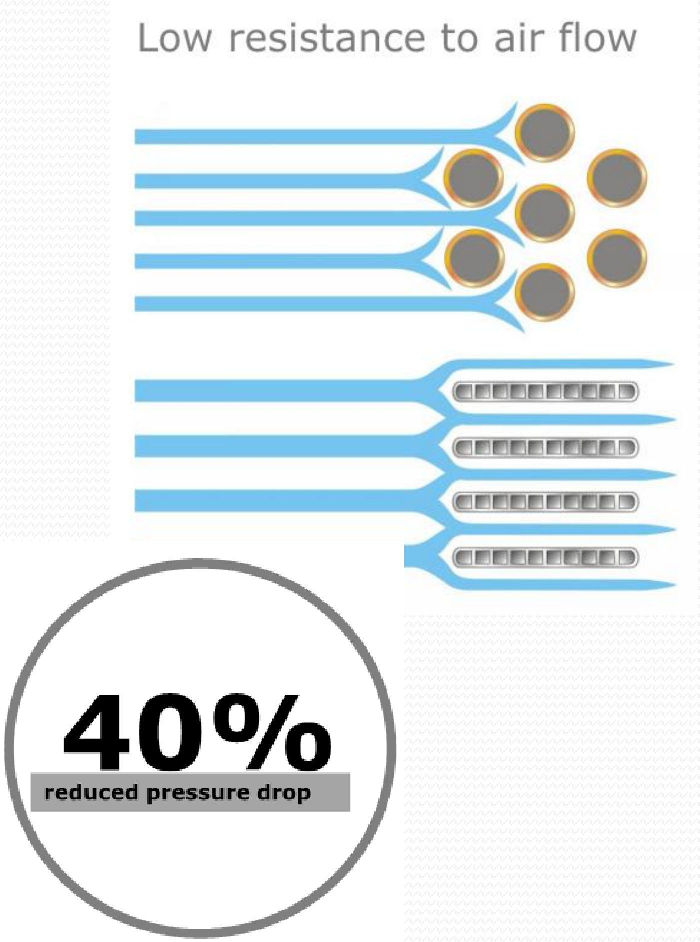
Limited Launch in 2012

1. Metallurgical bond – no galvanic corrosion.
2. MicroChannels – minimizing refrigerant charge and enhanced heat transfer
3. Superior louvred fin design – maximizing heat surface.
4. Ideal brazing configuration – no air gaps.
5. Vibrationless solid construction – low noise.



Micro-Channel Air Coils





$ less

System Integration

Plug-N-Play Geo Source Functions

Plug-N-Play Geo Source Functions

Plug-N-Play Geo Source Functions

Applied
$ less

Plug-N-Play Smart Tank

Other Advances

Other Recent GHP Advances

GHX Technology

- Coaxial and Multi-Pipe Vertical Loops
- High Conductivity Grouts
- New Drilling Methods

GHX Design Concepts

- Viewing GHX as Thermal Storage – Past Problem becomes Future Opportunity
- Hybrid and Campus Designs

GHX Design Tools

- Residential Savings Calculators – Fast and Accurate Feasibility without Load Calcs
- Detailed Hourly (or less) Energy Analysis Tools with GHX Modeling

A New Public Energy Policy Approach

- We need to take a new approach to Renewable / Efficiency Portfolio Standards
  - If the goal is to **save carbon and/or peak demand**
- “RPS/EPS” requirements need to be based on **Btu’s saved, or peak kW** not just annual kWh
  - Carbon lives in the combined electric and hydrocarbon fuel stream.
- GHPs are a Demand Side Renewable Thermal Energy Technology (like solar thermal)

And GHP Loops are

Thank You For Your Attention!

Questions?

If you ever need a hand you can reach me at:

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