Not Your Parent’s or Your Grandparent’s Heat Pump

From Load-Building Reverse Air Conditioners to Load-Reducing Heat Pumps

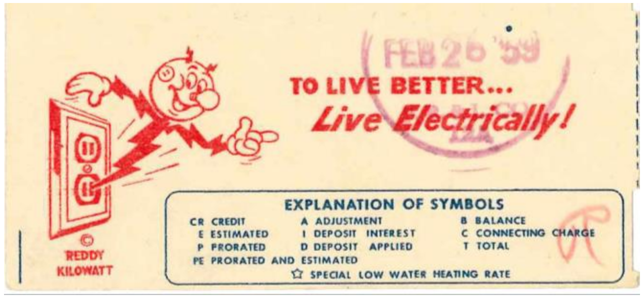
The Basics

- COP = Coefficient of Performance
  - Heating or cooling out/energy in (at given outdoor temperature)
- HSPF = Heating System Performance Factor = COP x 3.413.
  - Note HSPF also includes defrost and cycling losses
    - Avg COP of 2 x 3.413 = HSPF 6.8
    - Avg COP of 2.5 x 3.413 = HSPF 8.5
- Non-techies: the higher the number, the better

Bruce’s Introduction to Heat Pumps

The 1980’s

The Growth of Electric Heat



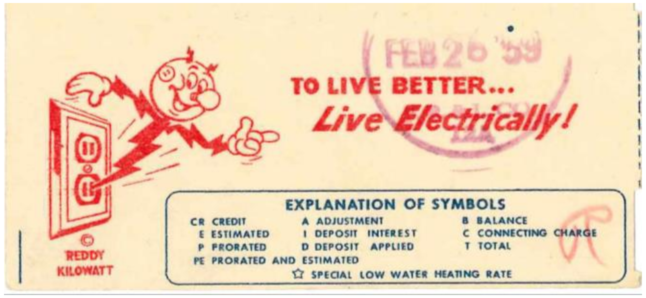
- Nation saw a 400% increase in the use of electric heat between 1950 and 1970
- 99.4% of new single-family homes in Seattle City Light’s territory were heated electrically by 1958

Hail the Reversing Valve

- So named because it “reverses the normal” flow of the refrigerant in an air conditioner
- Heat pumps are still called ‘reverse air conditioners’ in parts of the world

Live Better Electrically (LBL)

- LBL was launched in 1956
- A very successful consumer facing promotion of all things electric
  - Over 600 manufacturers, including General Electric and Westinghouse
  - Over 900 utilities
  - Coal companies, railroads and insulation companies



Promote Electric Heating!

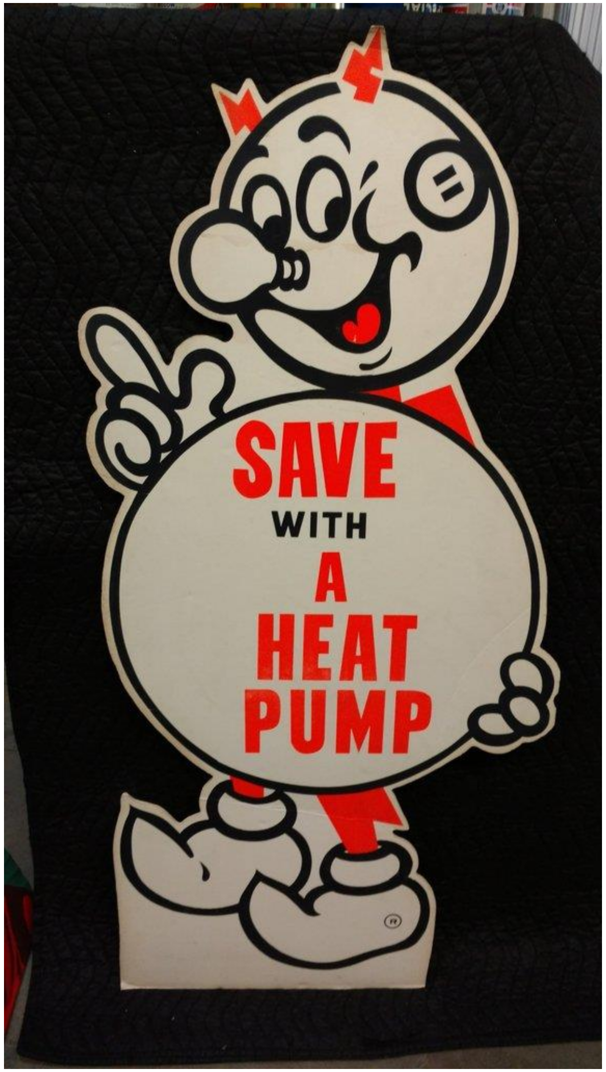
- Tactics like the “Live Better Electrically Gold Medallion Home” promoted the use of electric heat

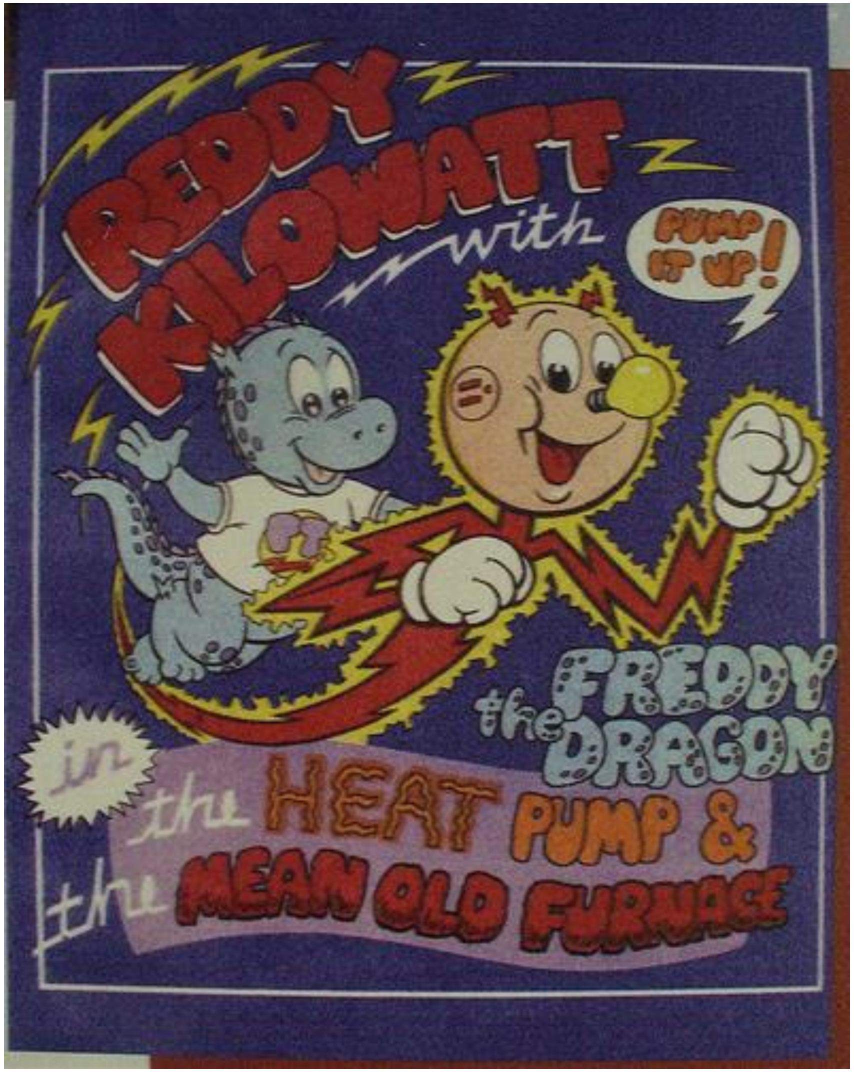
Living Better Electronically Campaign

Better Homes & Gardens
October 1958

ELECTRIC HEATING. Many Medallion homes feature electric heating, too. These are awarded a special Gold Medallion. The all-electric heat pump, shown here in the home of Mr. and Mrs. William Isaac of Beverly Hills, California, provides year-round comfort from a single unit which automatically heats or cools as the weather requires.

Promotional Materials





Things were going well

February 1959: "…consulting engineers and residential builders appear to be among the strongest champions of this combination heating and cooling equipment." Major electric utilities also recognized "the load-leveling potential of widespread heat pump use and are actively promoting this highly efficient method of year-round air conditioning…"

But then…

June 1960: Recent designs and unfortunate installation and service practices are combining to cause trouble with some heat pumps — poor performance on heating at best, burned-out compressors at worst — according to a contractor-manufacturer who says he's called 'the guinea pig of the heat pump.'"

Historic Heat Pump Performance

Climate Zone	Characteristic	Forced-Air Furnace	Zonal	Heat Pump
1	Number of Homes	55	847	121
	Percent	5%	83%	12%
	Average Size (sq.ft.)	2301	1789	2503
	Average UA (Btu/F)	488	378	578
	Average UA/sq.ft. (Btu/F)	0.212	0.211	0.231
	Average Total Use (kWh/yr)	21,294	17,192	25,747
	Average Total Use (kWh/sq.ft./yr)	9.7	11.4	10.9
	Average Heating Use (kWh/yr)	9106	4822	8431
	Average Heating Use (kWh/sq.ft./yr)	4.1	3.1	3.6

Source: Bonneville's Super Good Cents Sub-Metering Project Data Set Through December 1990.

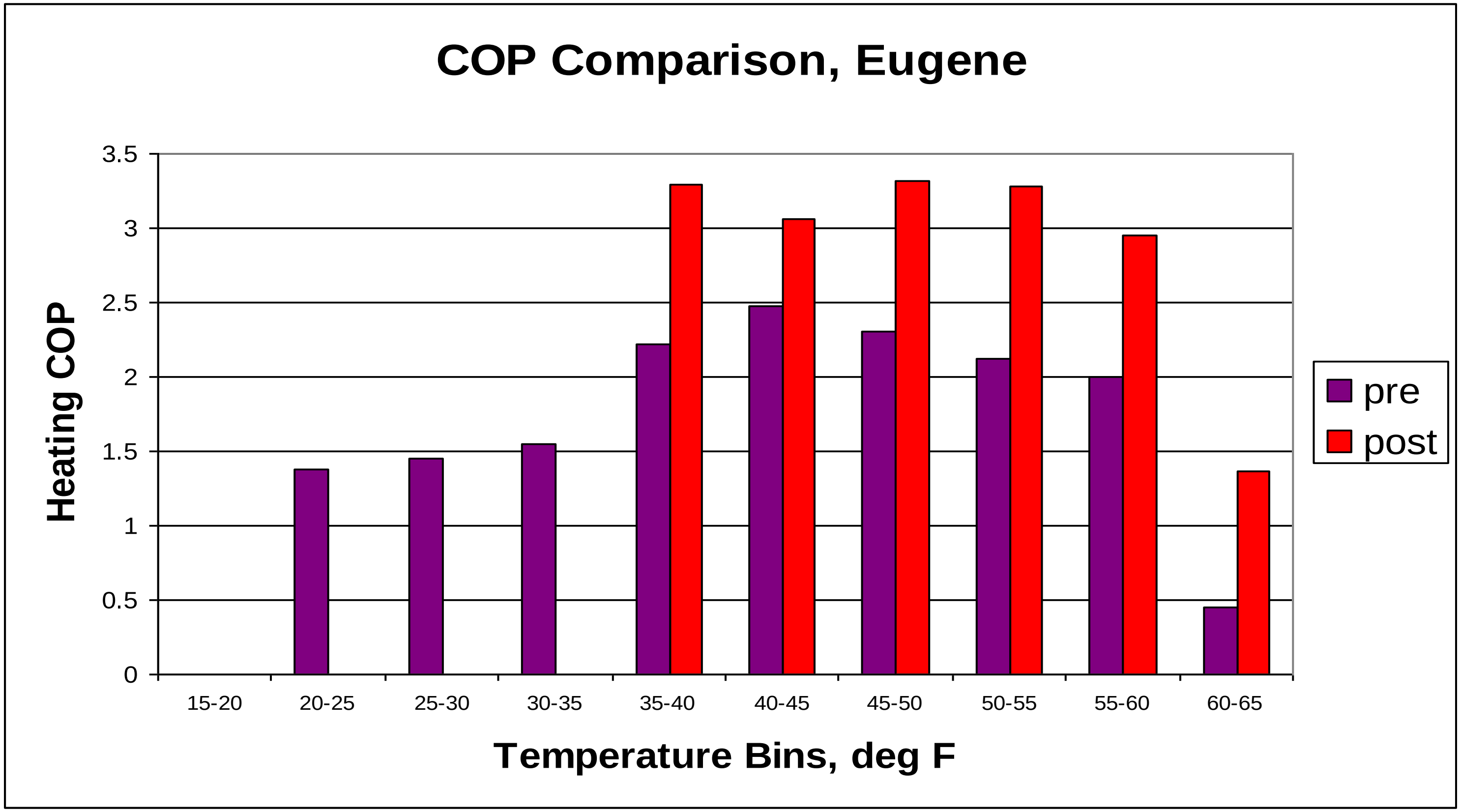
Summary of Measured Annual Heating Performance

(Second Data Set) 2006-2007 winter

Site	COP	"HSPF"	Target HSPF	Comments
Bend (410a)	**1.4**	**4.8**	**9.0**	Dropped out of program after 3 months of monitoring
Boise (410a)	**2.2**	**7.4**	**8.6**	Excessive defrost energy usage corrected late in monitoring period
Ashton (410a)	**1.1**	**3.6**	**7.7**	System oversized vs. heating load
Moses Lake (22)	**2.7**	**9.3**	**9.1**	Defective TXV on indoor unit replaced soon after initial installation
Deer Is (410a)	**2.9**	**10.0**	**10.9**	
Shelton (410a)	**2.4**	**8.2**	**10.2**	Possible measurement problem (air mixing on return side).
Roseburg (410a)	**2.4**	**8.2**	**10.3**	Same unit as Bend; much better performance. Very limited heating data given system installed in late March.

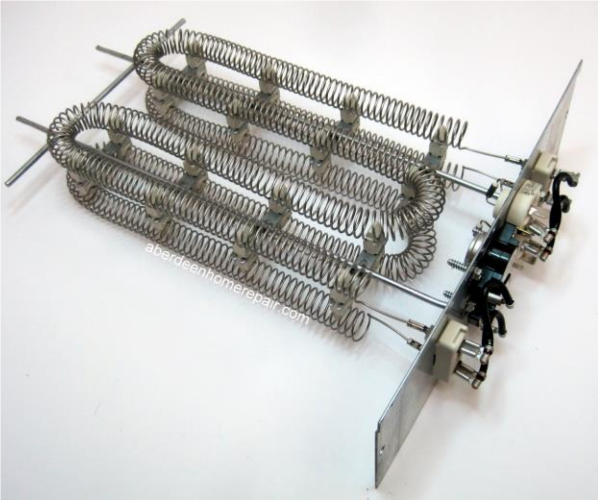
Sources: Bob Davis / Ecotope, David Robison / Stellar Processes, 2008 ACEEE Summer Meeting

Good COP Bad COP



Sources: Bob Davis / Ecotope, David Robison / Stellar Processes, 2008 ACEEE Summer Meeting

Why Did Performance Suffer?



- Maybe if you build a heat pump as a reverse air conditioner with the goal of building winter load…
- … you're not worried about cold climate efficiency.

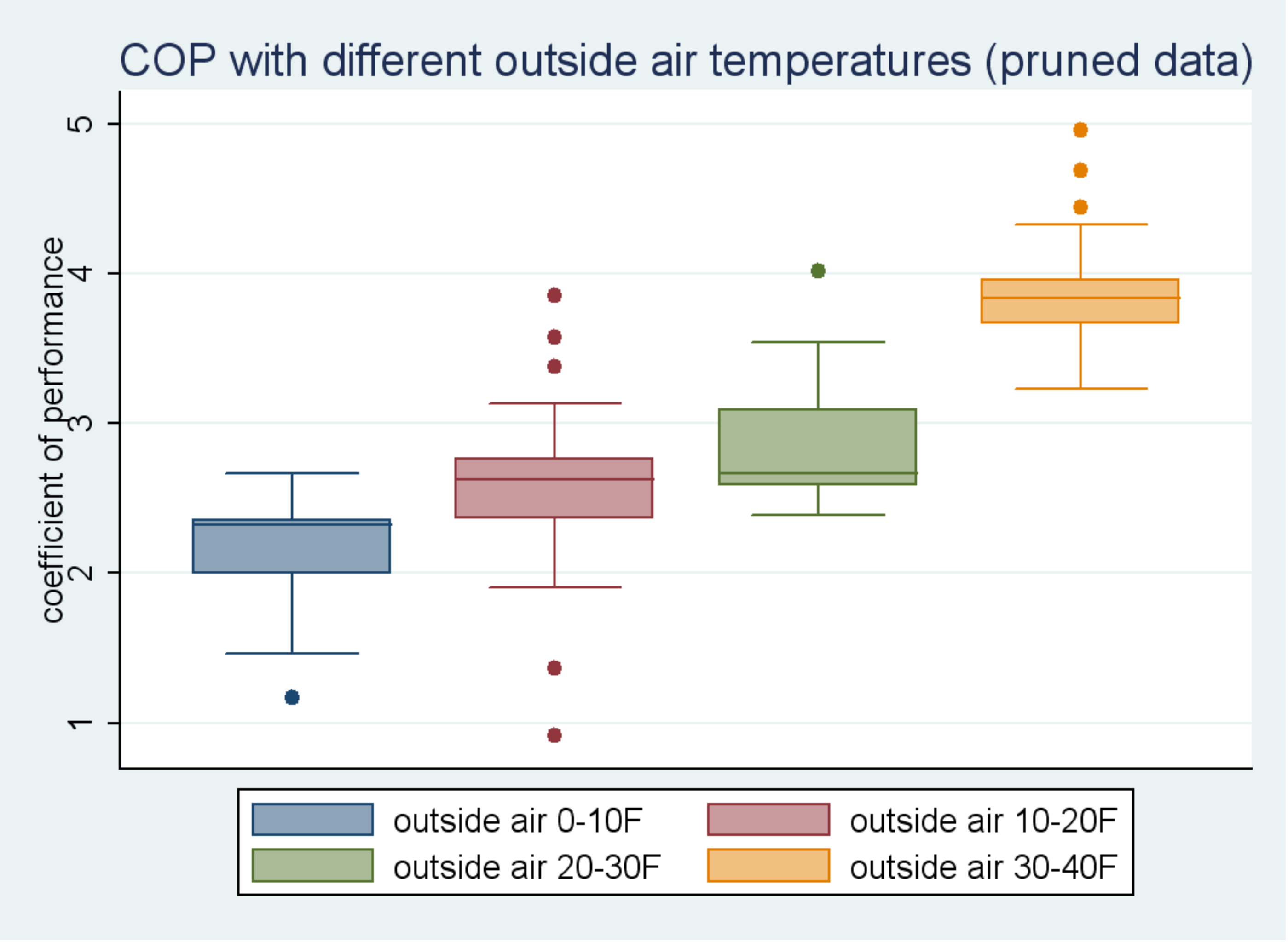
Heat Pump Developments: 1960-2010

Issue	Old School	Sort of New School	New School
Strip heat control	None	Lockouts	No
Defrost	Timed	On demand	Demand no strip heat
Refrigerant flow	Capillary Tube	Fixed Orifice/TXV	EEV
Compressor Efficiency	Hermetic/Piston	Scroll	Inverter
Duct Design	Good	Lousy	No Ducts
Fan	Belt Driven	Direct Drive/Shaded Pole	ECM *(only better with good ducts)

Cold Weather Heat Pumps. Many Styles

- Ductless
- Mini Ducted
- Full ducted systems

No Bad COP

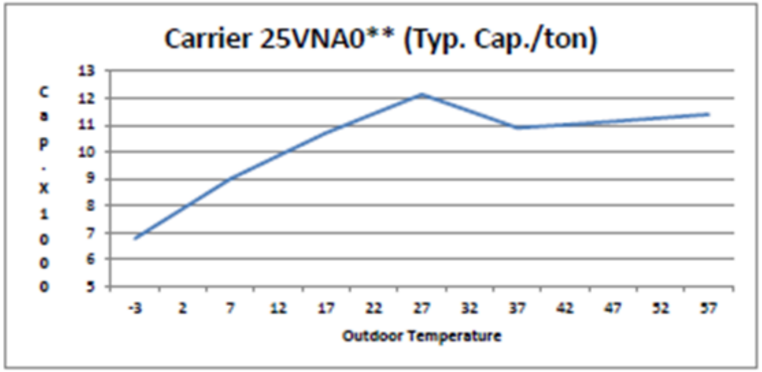


Sources: Placeholder for sources if needed.

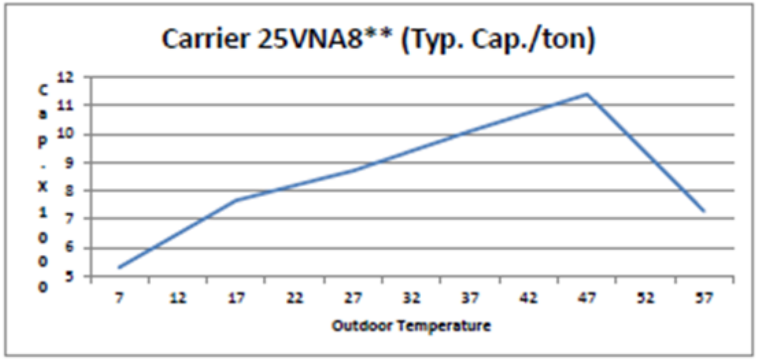
The Unknowns (Sizing)

- How best to size the systems for maximum efficiency
  - Traditional Around 30F
  - Can we go lower?
  - Can we design for the Winter design temperature (at least West of the Cascades)?
- Is the low output as important as the high output in order to prevent over cycling?

No Bad COP



Carrier 25VNA0** (Typ. Cap./ton)
Cap. x 1000
13
12
11
10
9
8
7
6
5
-3
2
7
12
17
22
27
32
37
42
47
52
57
Outdoor Temperature



Carrier 25VNA8** (Typ. Cap./ton)
Cap. x 1000
12
11
10
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7
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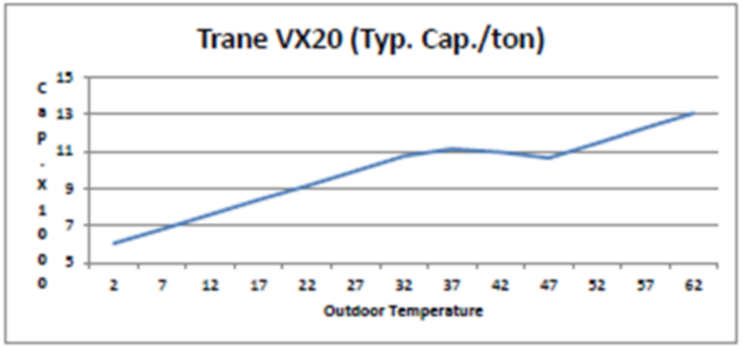
7
12
17
22
27
32
37
42
47
52
57
Outdoor Temperature



Trane VX20 (Typ. Cap./ton)
Cap. x 1000
15
13
11
9
7
5
2
7
12
17
22
27
32
37
42
47
52
57
62
Outdoor Temperature

.

Old School Sizing

Heat Pump Capacity Ratings

2.5 ton

17F= 15,000

47F=28,400

3 ton

17 F= 21,600

47 F=34,200

3.5 ton

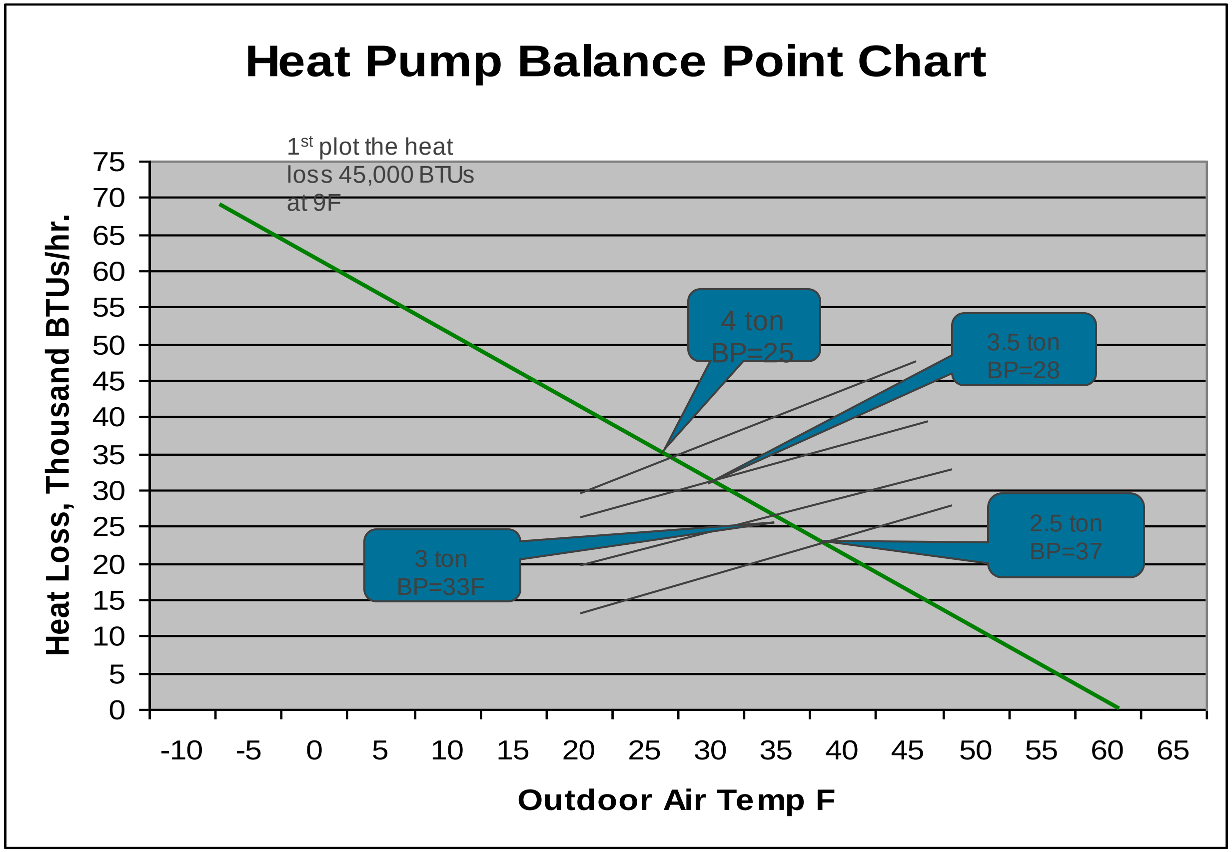
17 F= 26,200

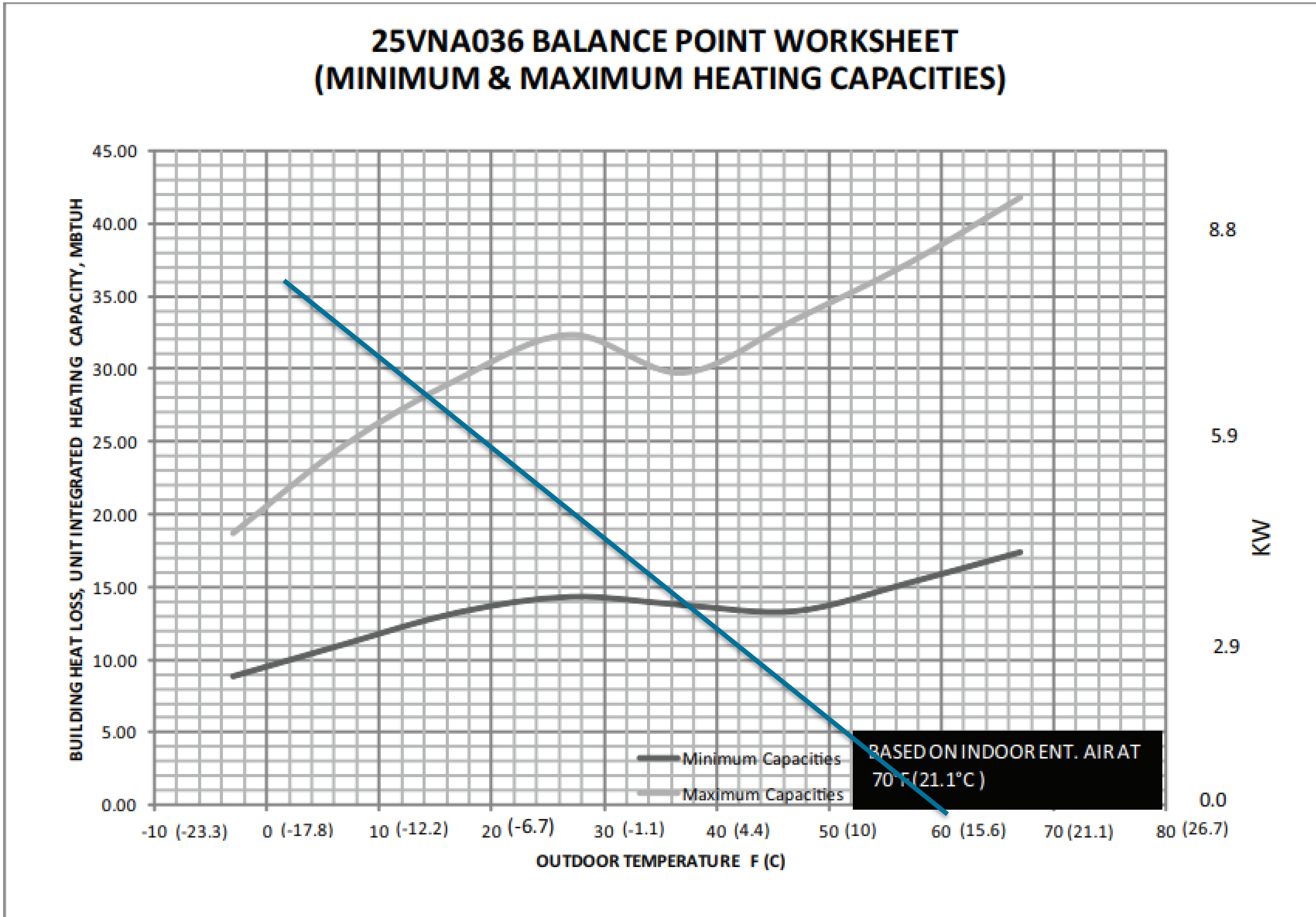
47F =39,000

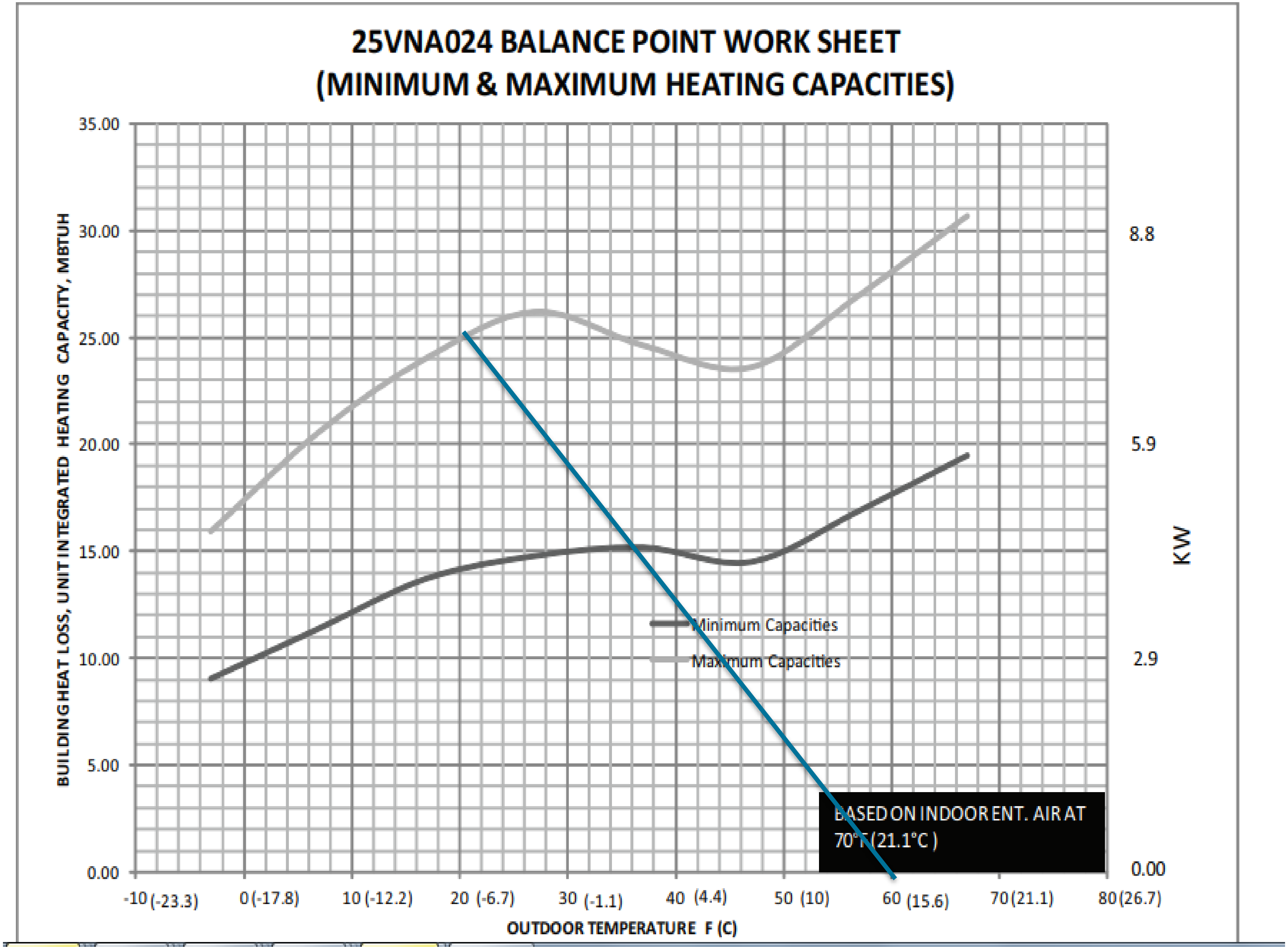
4 ton

17F =29,200

47F=47,00




25VNA036 BALANCE POINT WORKSHEET
(MINIMUM & MAXIMUM HEATING CAPACITIES)
BUILDING HEAT LOSS, UNIT INTEGRATED HEATING CAPACITY, MBTUH
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
8.8
5.9
2.9
0.0
KW
Minimum Capacities
Maximum Capacities
BASED ON INDOOR ENT. AIR AT 70°F (21.1°C)
-10 (-23.3)
0 (-17.8)
10 (-12.2)
20 (-6.7)
30 (-1.1)
40 (4.4)
50 (10)
60 (15.6)
70 (21.1)
80 (26.7)
OUTDOOR TEMPERATURE F (C)


25VNA024 BALANCE POINT WORK SHEET
(MINIMUM & MAXIMUM HEATING CAPACITIES)
BUILDING HEAT LOSS, UNIT INTEGRATED HEATING CAPACITY, MBTUH
KW
OUTDOOR TEMPERATURE F (C)
Minimum Capacities
Maximum Capacities
BASED ON INDOOR ENT. AIR AT 70°F (21.1°C)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
8.8
5.9
2.9
0.00
-10 (-23.3)
0 (-17.8)
10 (-12.2)
20 (-6.7)
30 (-1.1)
40 (4.4)
50 (10)
60 (15.6)
70 (21.1)
80 (26.7)

The Unknowns (Data Collection)

- Most of the controllers are WI-FI enabled:
  - Can programs use this data for quality control and energy use analysis?
  - Can homeowners be nudged with data to better manage their systems?

The Unknowns (Standby loses)

- What are they?
  - What is the energy use and logic of heating the compressor?
  - Other
  - Significant saving potential Maybe as high 750kWh/year

The Unknowns (Ducts)

- Duct sizing, what capacity do we design for? Max air flow or somewhere in the middle?
- How much more important is duct insulation and duct sealing on these systems?
- Can we design for the Winter design temperature (at least West of the Cascades)?

The Unknowns (Defrost)

- May be more savings from intelligent defrost that from the gain in HSPF
  - Do we need the Aux heat to be on during defrost?
  - Can they just bring on 5 K of Aux heat?
  - At lower operating speeds do they defrost more or less tan a standard heat pump

The Future Of Heat Pumps Is Now

This New, Hip Heat Pump Technology May Mean:

- A dramatic reduction in peak demand at the house level
  - Average strip heat according to RBSA is 12.2KW
- Dramatic reduction in energy use
  - High COPS
  - Less energy for defrost
  - No aux heat usage

BUT…. it all depends on better understanding of the technology and programs that mesh well in the real world and deliver real energy savings

Feedback: What did Bruce…

1. Get Wrong
2. Failed to Mention
3. Not understand the importance of?