Air Source Heat Pumps: Measured Performance & Best Practices

NESEA BE19

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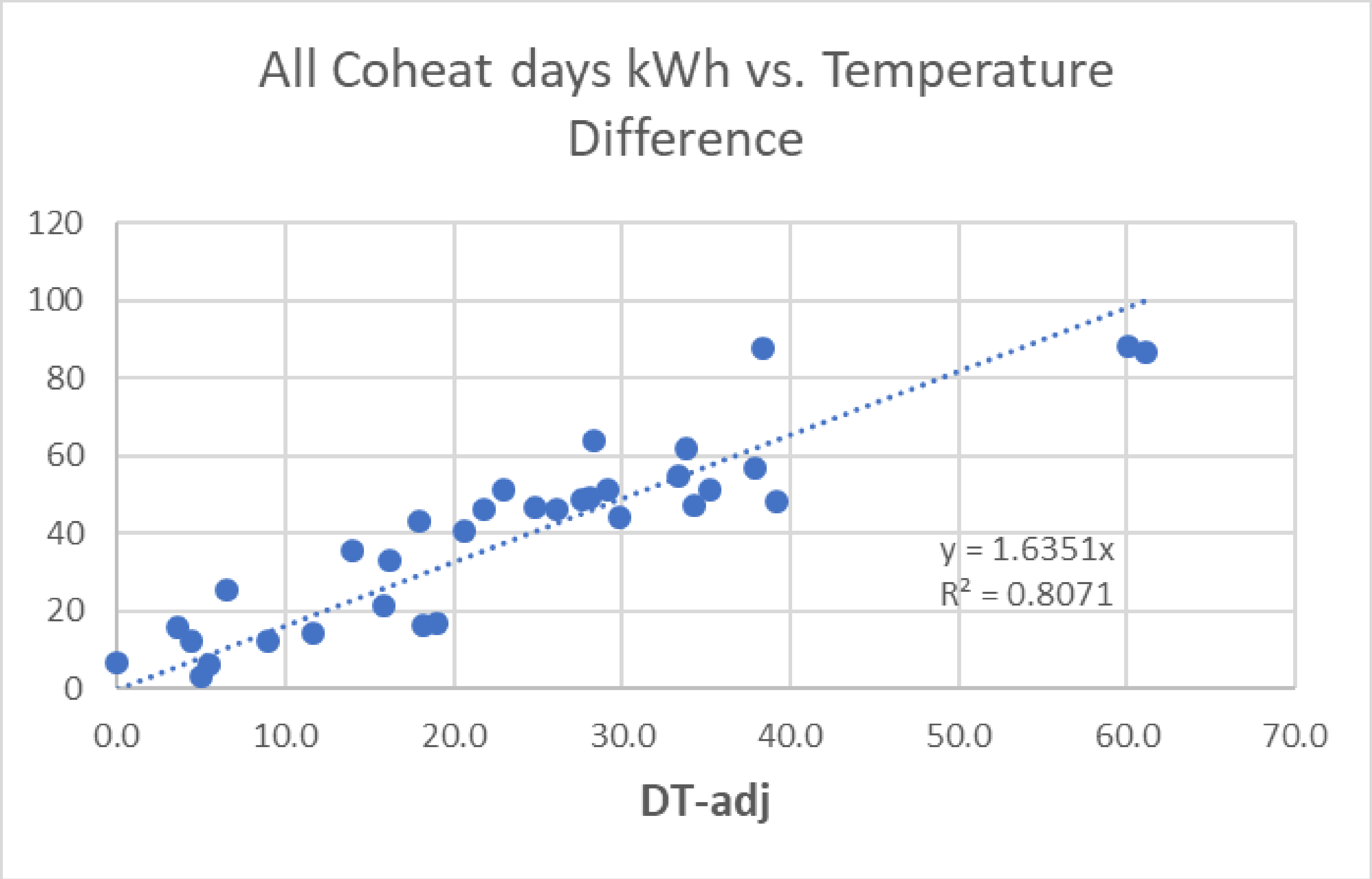
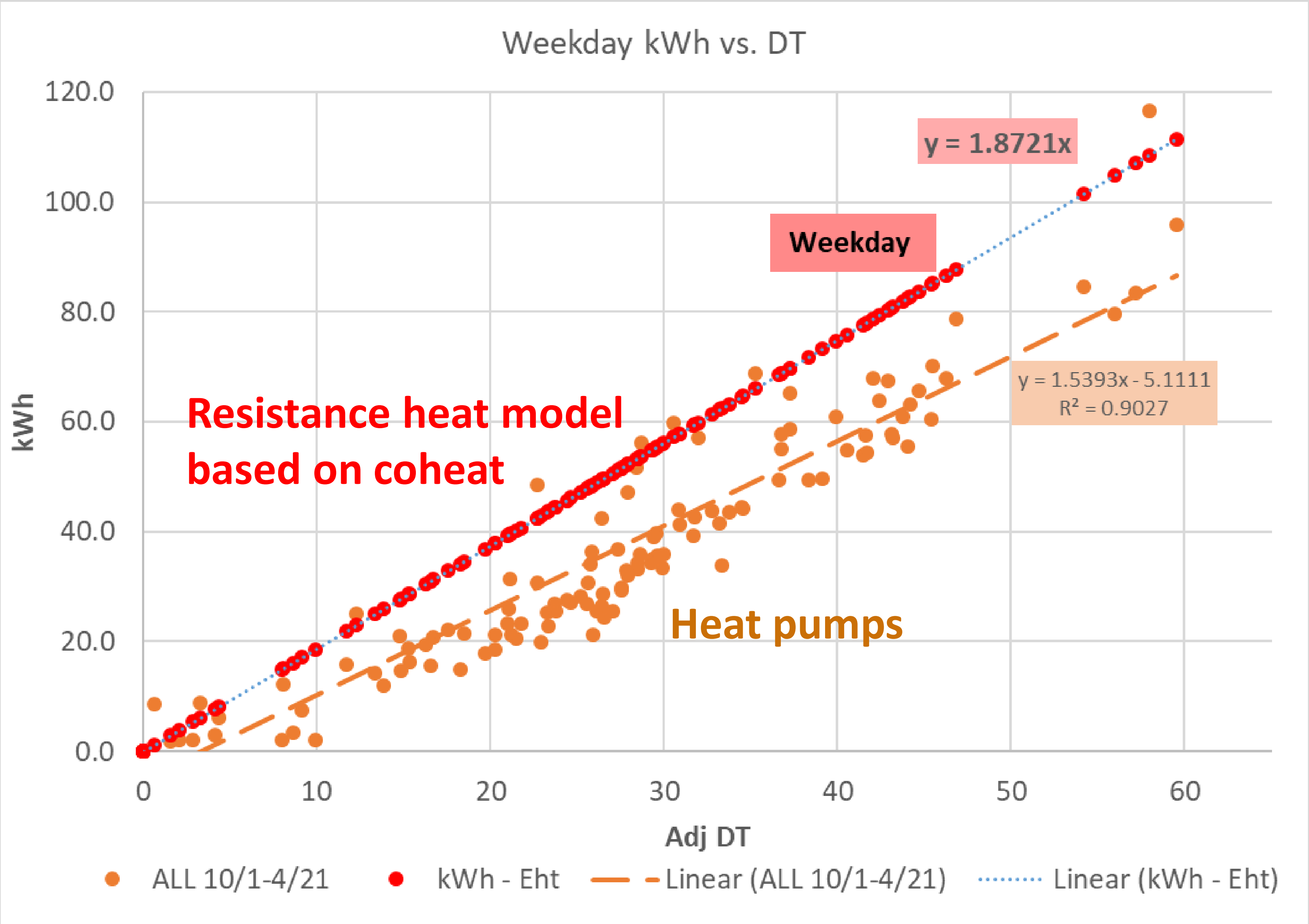


Daily averages. DT-adj is base 60, so DT-adj of 50 is 10°F.

EFG – Coheat Test

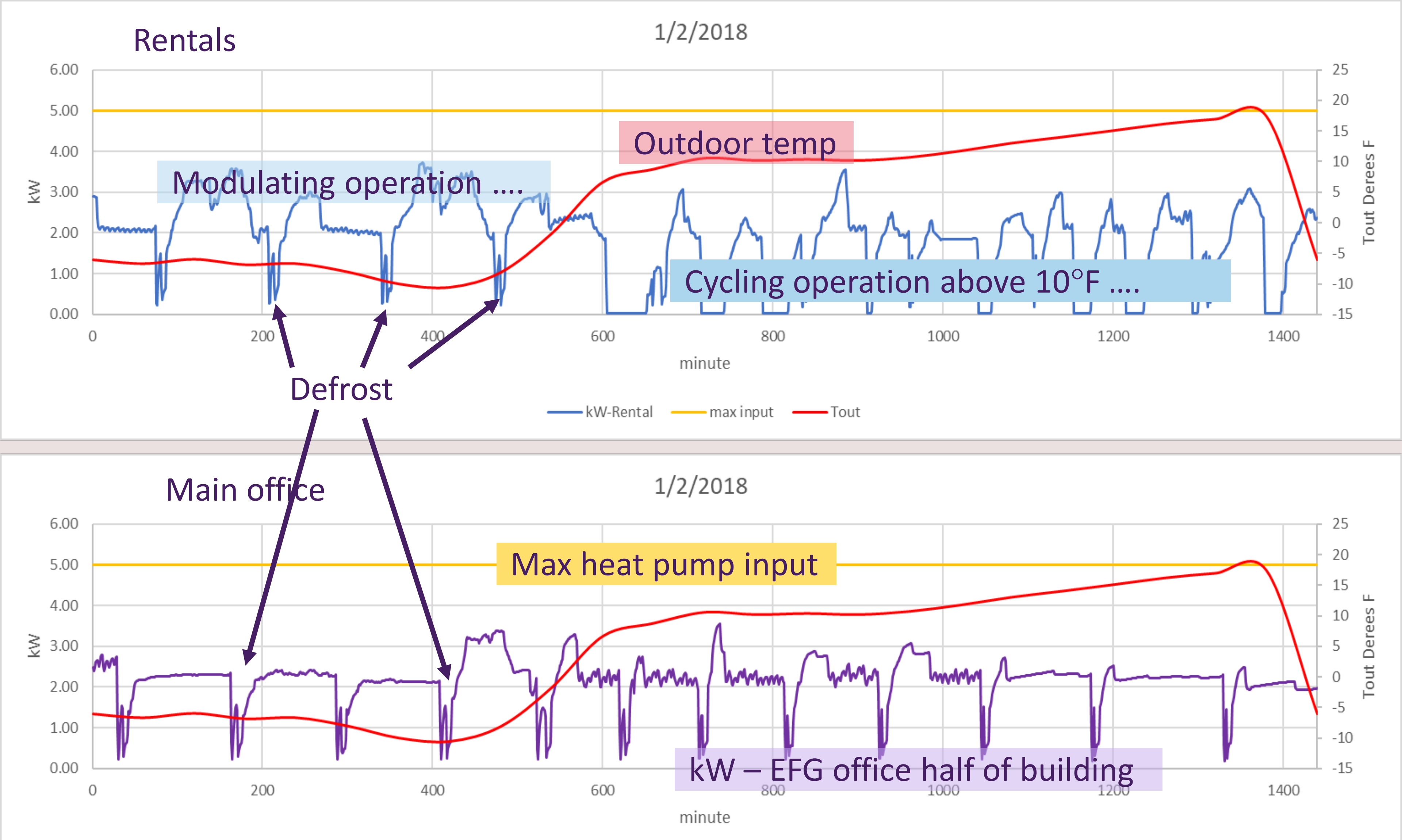
- Sum of load delivered (heat loss) divided byactual heat pump energy (input) = COP
- Daily data, using daily DT
  - Tried night only, no solar days – poorer correlation between model and actual; didn't change answer
  - Separated weekday from weekend: schedule, ventilation vary

- Net COP_H for 1/10/17 to 1/5/18 = **1.4**
  - *Not* counting resistance heat periods


Weekday kWh vs. DT
120.0
100.0
80.0
60.0
40.0
20.0
0.0
kWh
0
10
20
30
40
50
60
Adj DT
y = 1.8721x
Weekday
Resistance heat model based on coheat
y = 1.5393x - 5.1111
R² = 0.9027
Heat pumps
ALL 10/1-4/21
kWh - Eht
Linear (ALL 10/1-4/21)
Linear (kWh - Eht)

Cold day, modulates @50%; COP=1.2 (*1.8**)

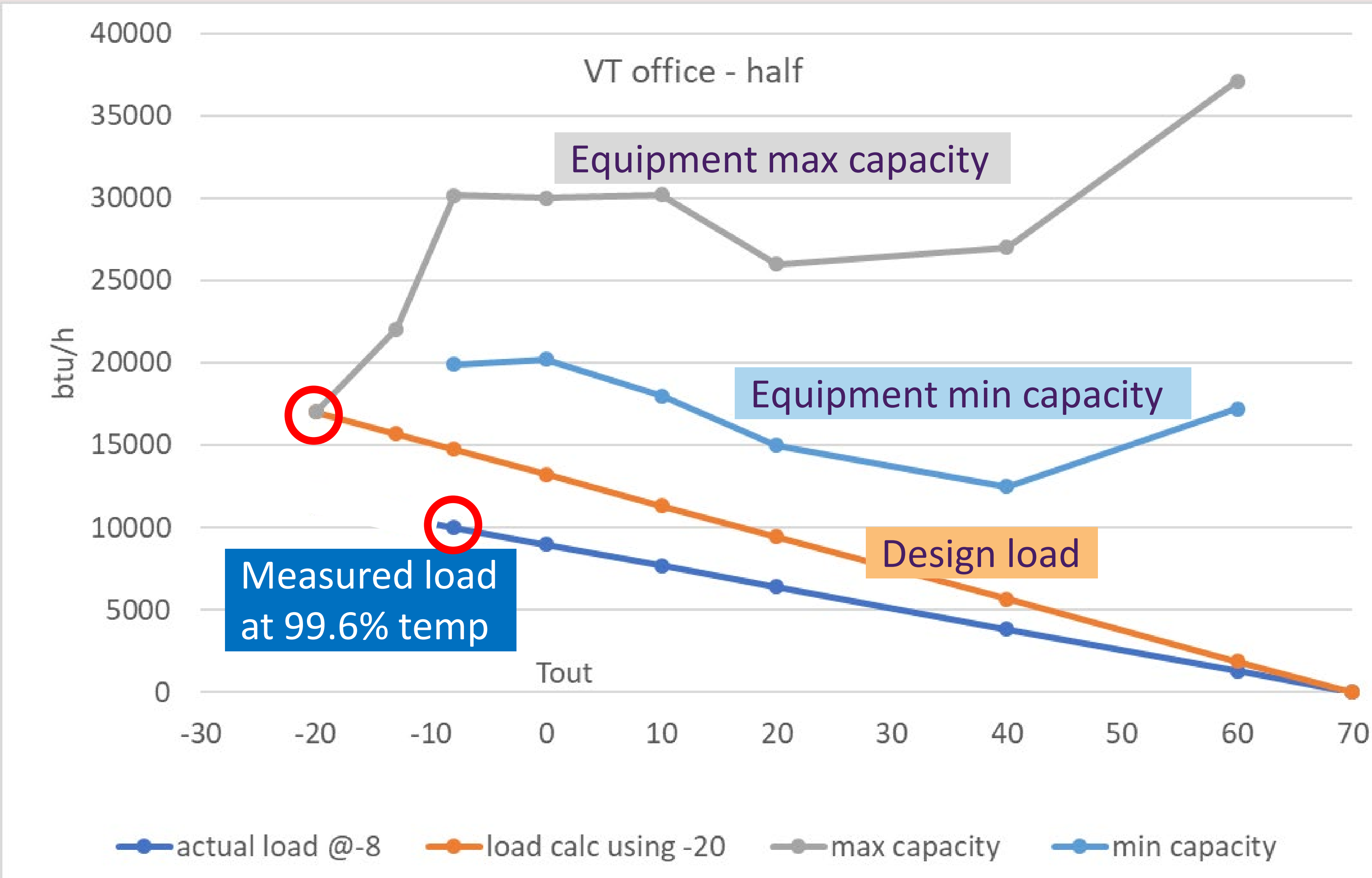
**COP should be*



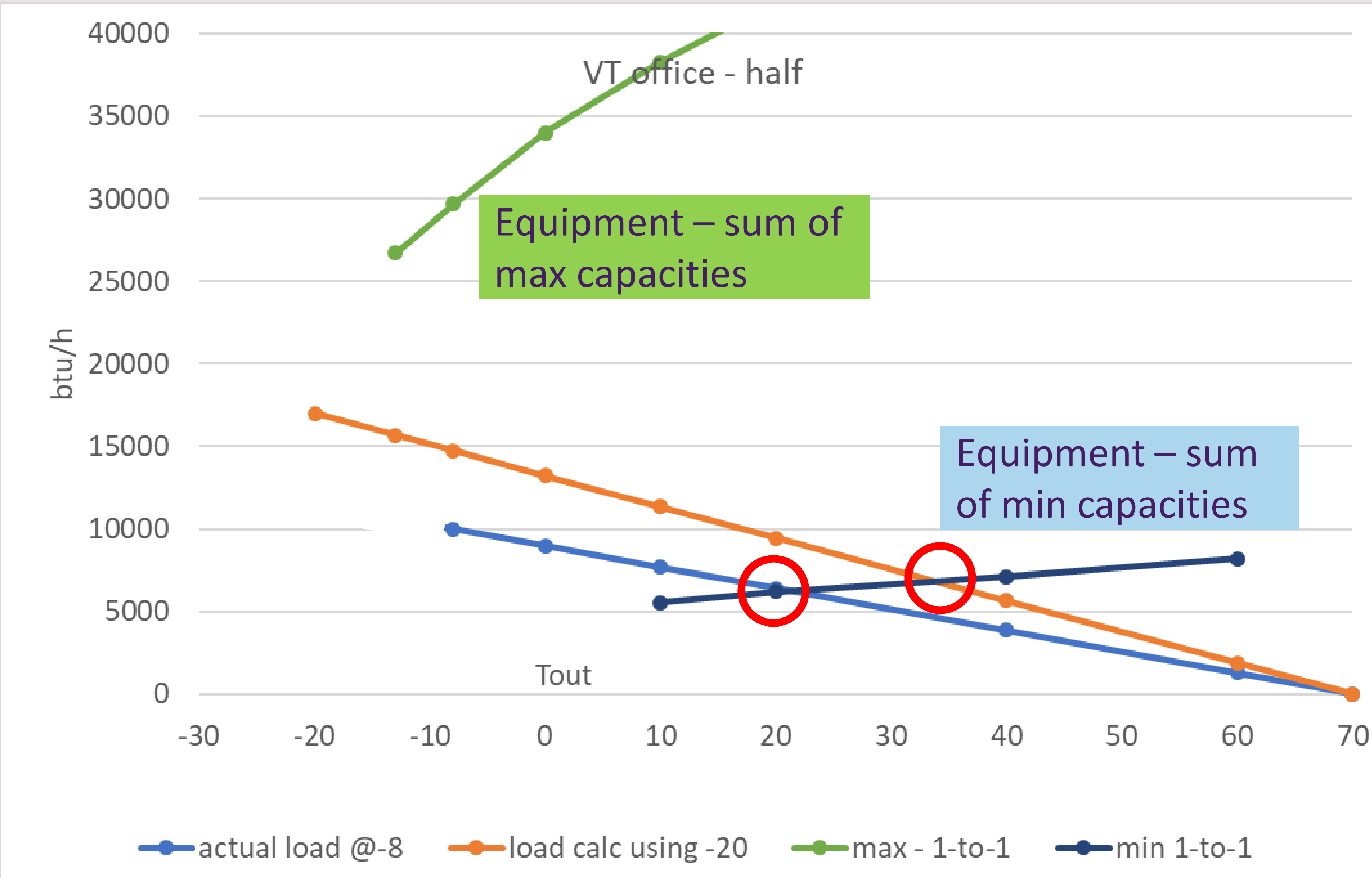
Conclusions

- Oversizing leads to underperformance
  - Very little of heating season is in modulating mode
  - Multi-zone = less turn-down than single = more critical
- Cycling behavior starts at much colder temperatures than it should
- Rental side cycles more
  - Smaller terminals upstairs = bigger mismatch between individual unit loads and outdoor capacity
  - Asynchronous calls for heat

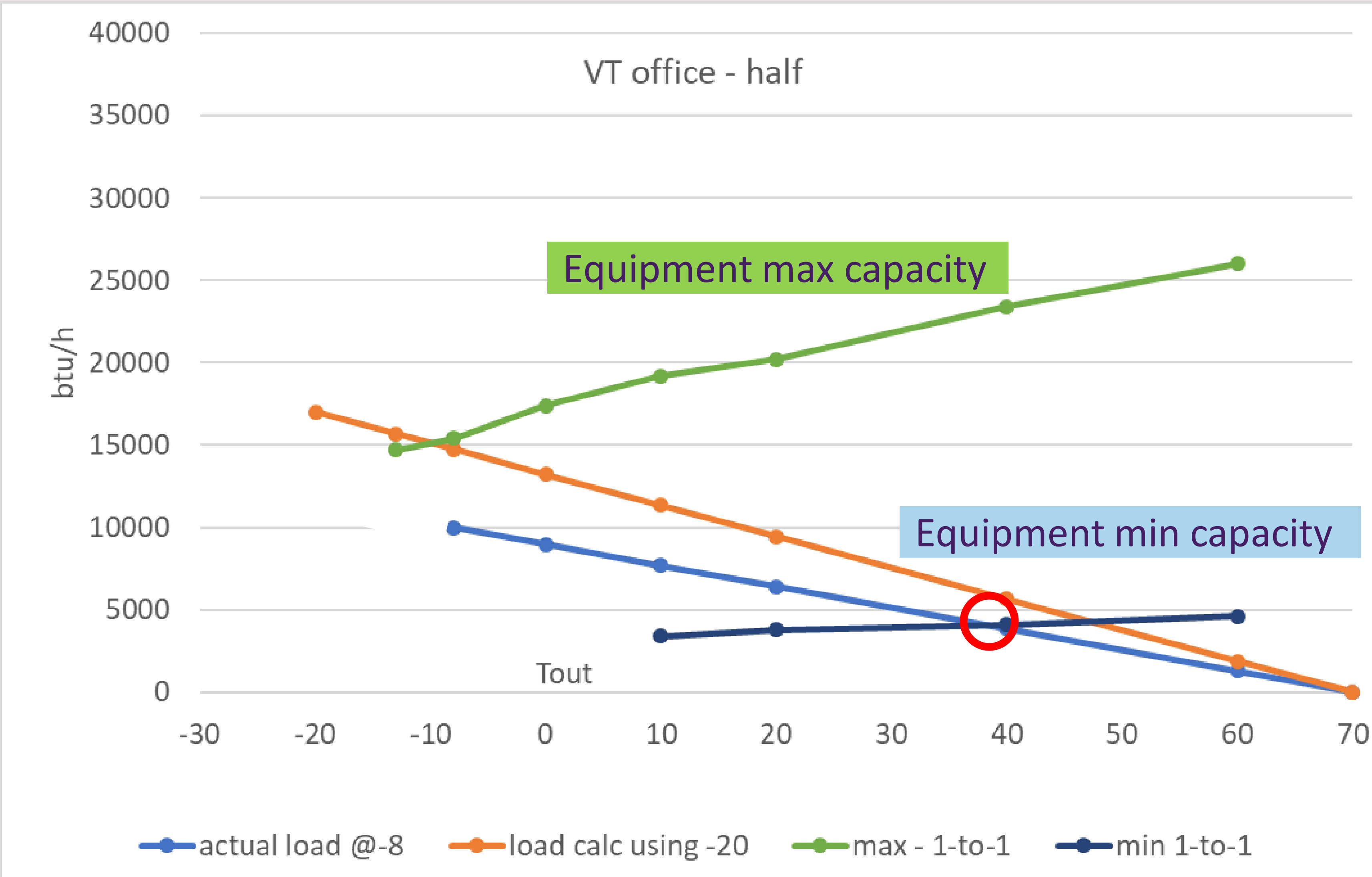
Sizing – what they got (equipment specs)



If rental was 6+6+15, single zone units



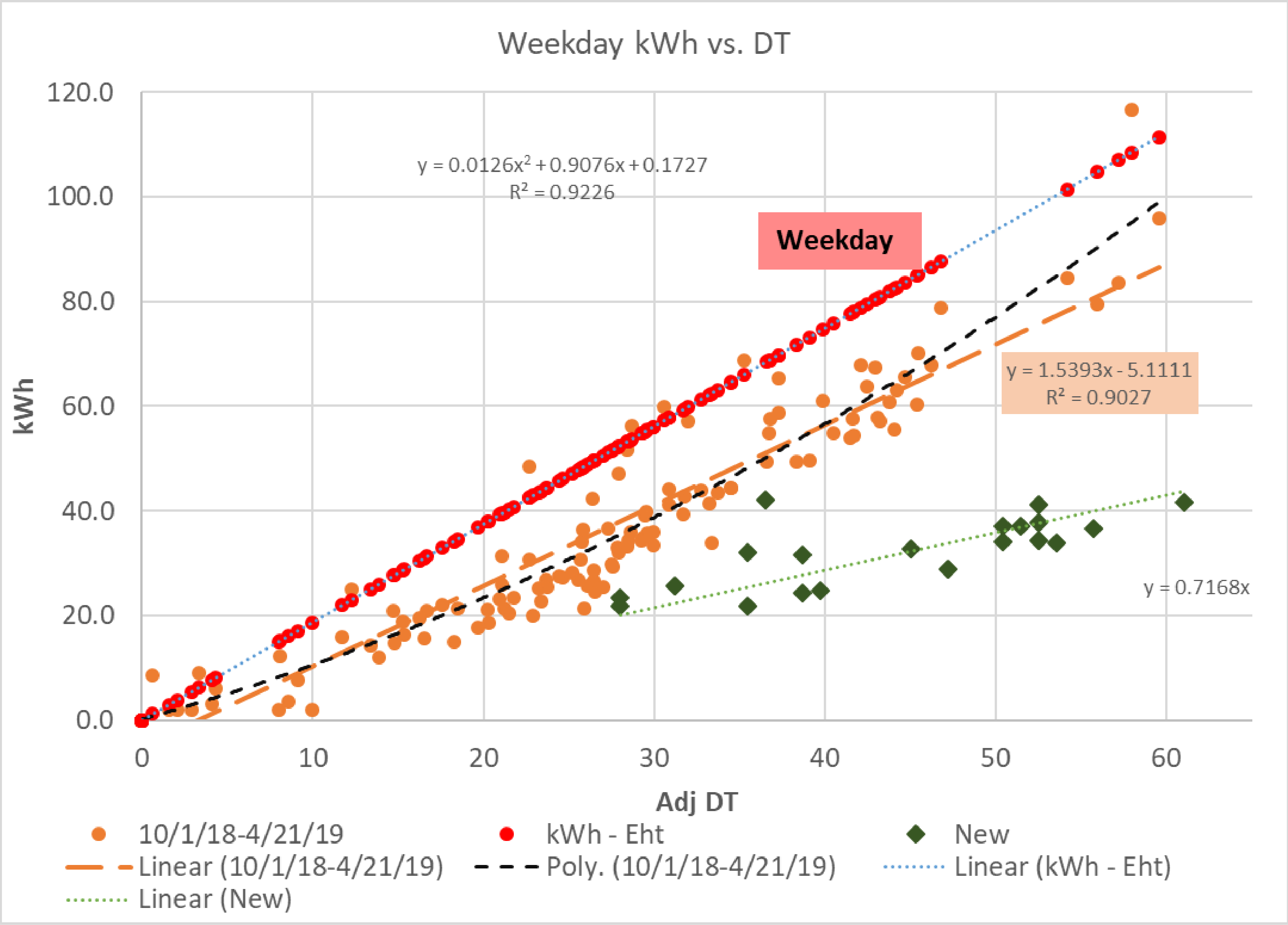
Even better: (1) 15k, ducted unit



Before – Two Multizone:

After – (5) 1-to-1 outdoor units:

Success (so far):



Multi-zone – Residential loads:

- *Don't* choose a ductless zone for each room, and then choose an outdoor unit that can supply that number of zones
  - Most *existing* bedrooms have loads ***much*** too small for a ductless zone: ***1500-3000 btu/h at design***
- *Strongly recommended:*
  - Size each indoor terminal to the load it serves
  - Smallest indoor unit >= 1/3 of outdoor capacity
- Use more, smaller outdoor units (similar cost; redundancy is good) – even multiple 1-to-1's

Application_Note-1036-Applying_MXZ-C_Multi-Zone_Systems-20190103.pdf - Adobe Acrobat Pro DC

File Edit View Window Help

Mitsubishi Application Note 1036

Hom ... Applicat... ×

3 / 7 100% Sha

Proper Equipment selection

Outdoor units

Outdoor units should first be selected by the proper load done for the structure. The outdoor unit should not be selected based on how many indoor units are desired. If the outdoor unit is oversized just to provide a certain number of indoor units for each of the zones, overheating, humidity issues and higher than expected energy usage can occur. If the proper size outdoor unit doesn't provide enough indoor units/zones, the best option may be to combine some zones as needed with a ducted unit. Or, if there are only 2 or 3 small zones to condition, combining them and using a one to one system may be a better choice.

Indoor Units

Proper indoor unit sizing and selection is probably the most important part of applying an MXZ-C system. Too often the indoor units are used because a homeowner wants to have their own control without regard for oversizing. If an indoor unit nominal capacity is more than 50% higher than the maximum heating or cooling load in a space, it will be oversized and humidity, overheating and higher than expected system energy usage can occur. This space should not have its own indoor unit.

8.50 x 11.00 in

Multi / Single Applications

- *Note: all these suggestions apply to small multi-zone, not necessarily VRF/commercial applications*
- Distribution – where needed:
  - Use ducts vs. multiple oversized ductless heads
  - Use multiple 1-to-1 systems – bigger turn-down
  - Or, a hybrid:
    - 1 or 2 single-head DHPs for main living space(s), and
    - 1 compact-ducted for bedrooms w/short duct runs
    - Pay attention to duct static pressure specs !
- See multi-split section 12, ACCA Manual S (2014)

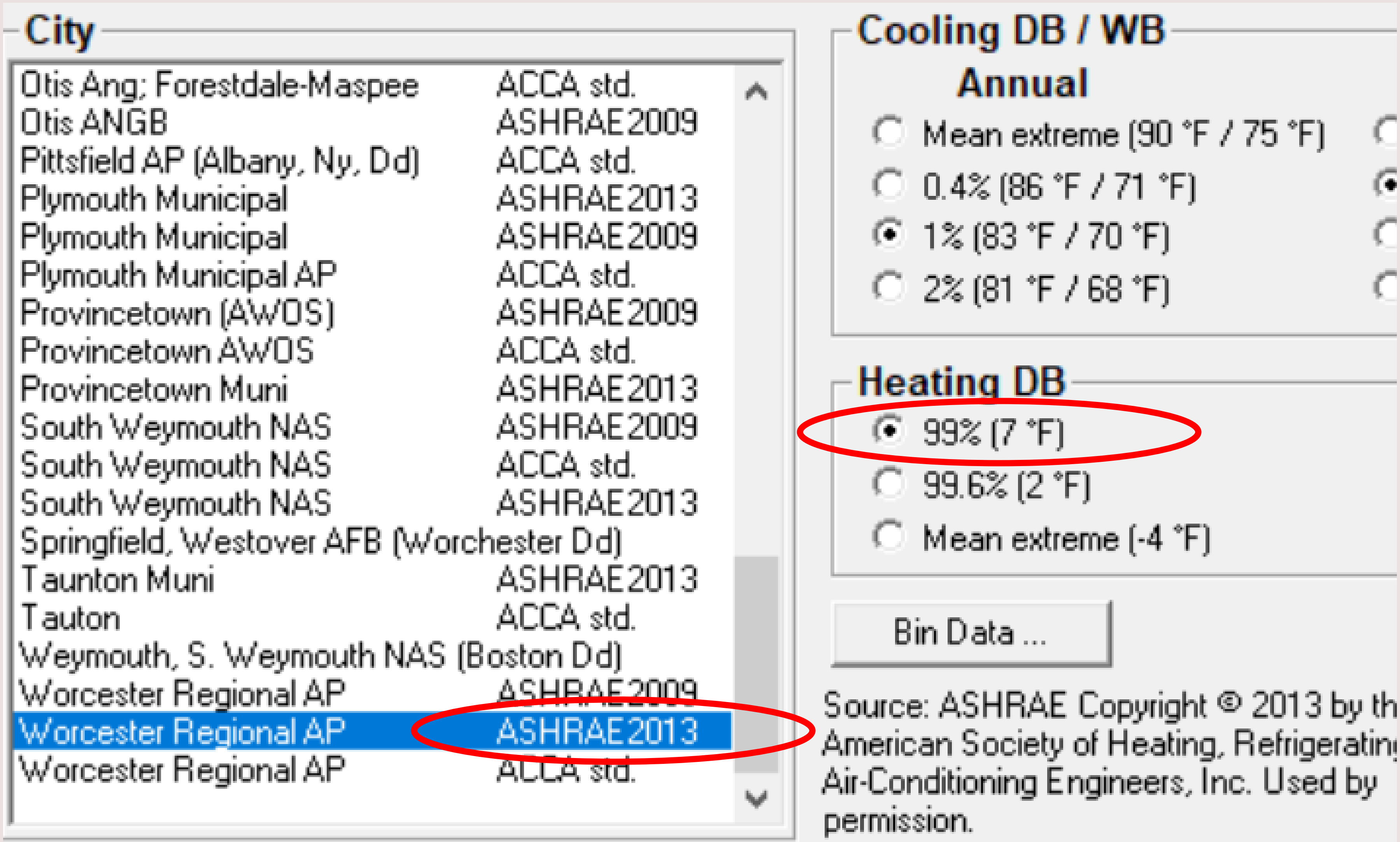
Sizing – Efficient New Con / DER

- Use equipment specs *at design conditions*
  - *Never* base on nominal capacity e.g. "1 ton"
- Do adjust capacity for long line sets, *and* for defrost in maritime climates
- Size equipment at 75-85% of heating load
  - Size smaller in colder locations (70% at Tdes <-10)
  - Boston and warmer, 80%+

Sizing – Efficient New Con / DER

- Install *just* enough aux heat (resistance, fan coil, or gas fireplace) to make up difference
  - Think, electric radiant underfloor in bath/kitchen… or duct heater in ventilation system
- Best: aux is completely disabled until needed
  - Or shut the breakers off! Probably never needed
  - We need better options to do this with automated controls

Design Conditions



Design Conditions

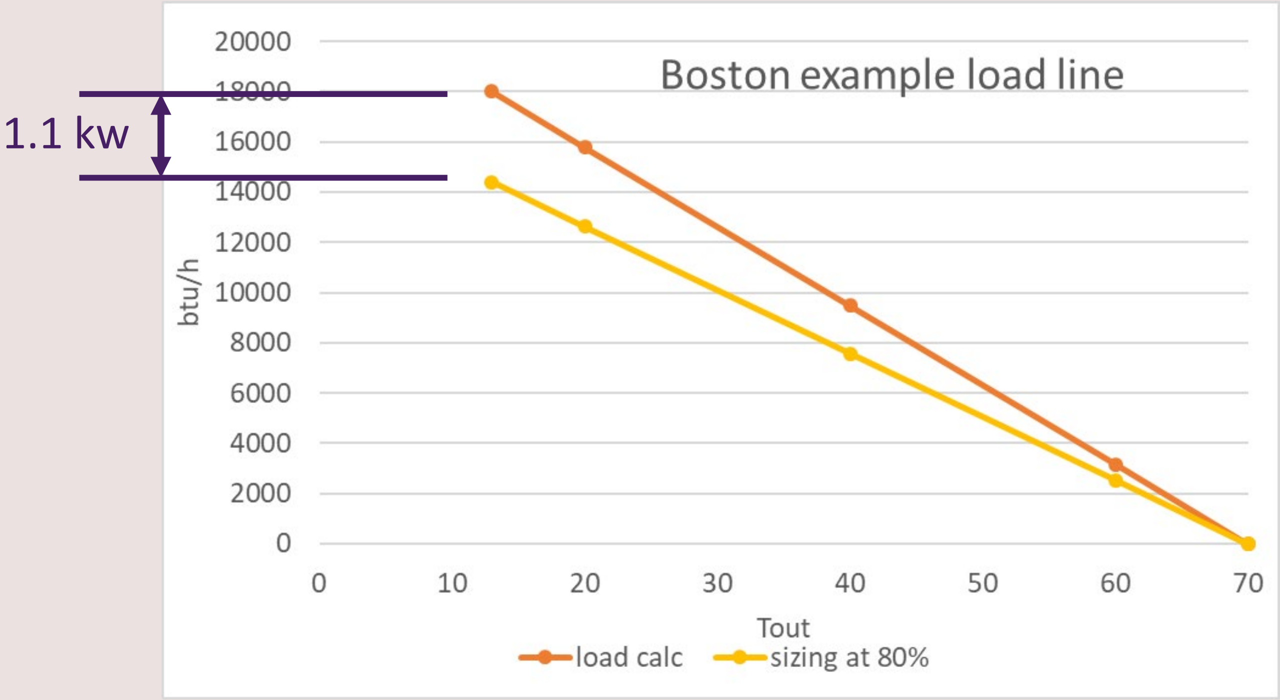
- Use the 99% design temperature
  - Based on the most recent data (typ. ASHRAE 2013)
- Range for MA, °F:
  - Provincetown: 18
  - Boston: 13
  - Chicopee: 5
  - North Adams: 3
- These may not seem low enough
  - Even careful calcs tend to overestimate the load
  - Manage comfort risk with *small* auxiliary heat capacity

Objective

- Select the heat pump operating range (max to min capacity) to cover as much of the heating season as possible
- Don't exceed the load at design temperature
- Maximize the turn-down (min speed as low as possible) to cover the range of loads

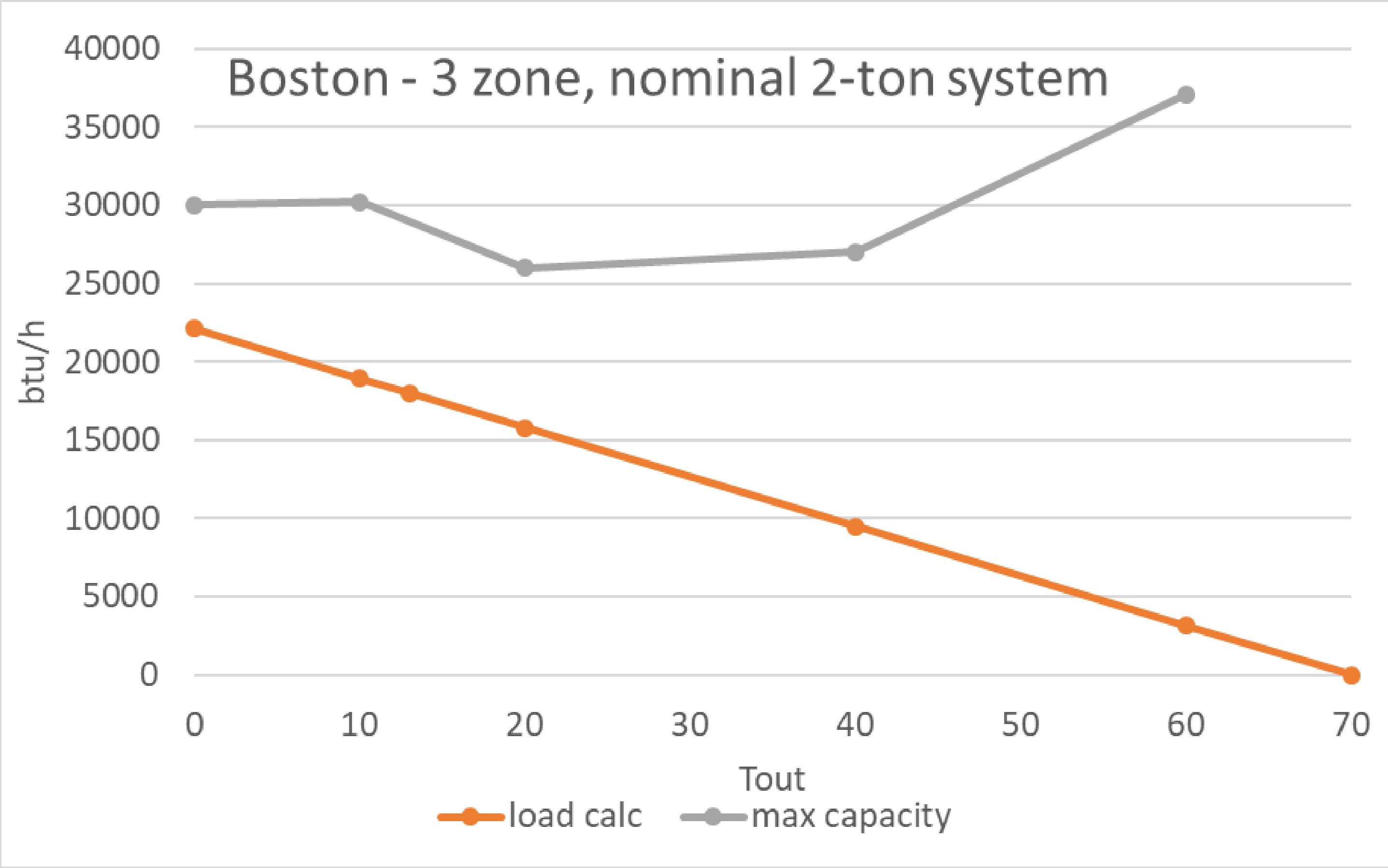
Boston Example

- 18,000 btu/h at 13°F
- 80% of 18,000 = 14,400 – heat pump design
  - 20% in auxiliary = 3,600 btu/h = 1.1 kW



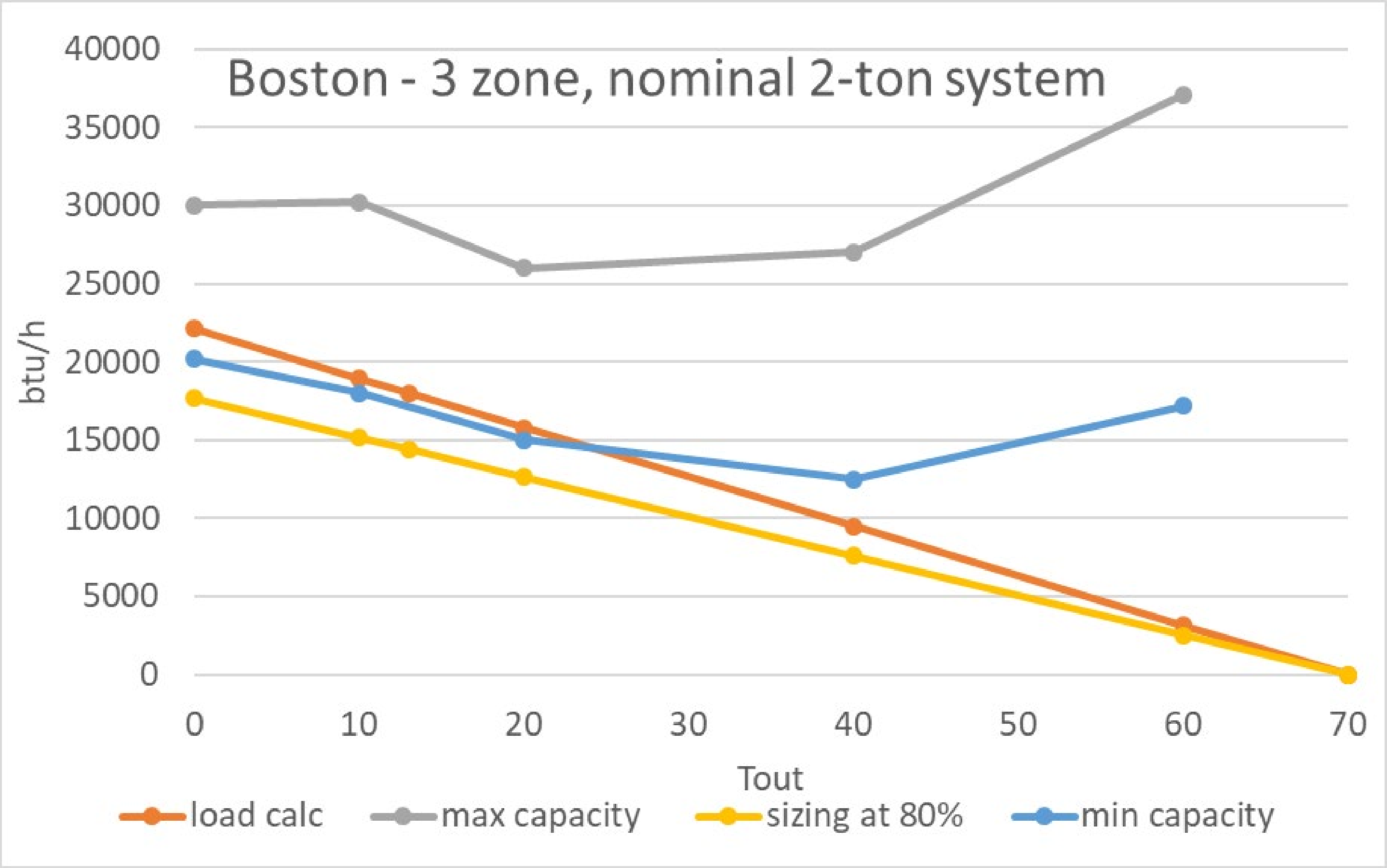
Same house, using mean extreme design temp: 3°F, Load -> 21,200

This might look like a reasonable choice, especially if you wanted 3 zones. It's only a little oversized… right?

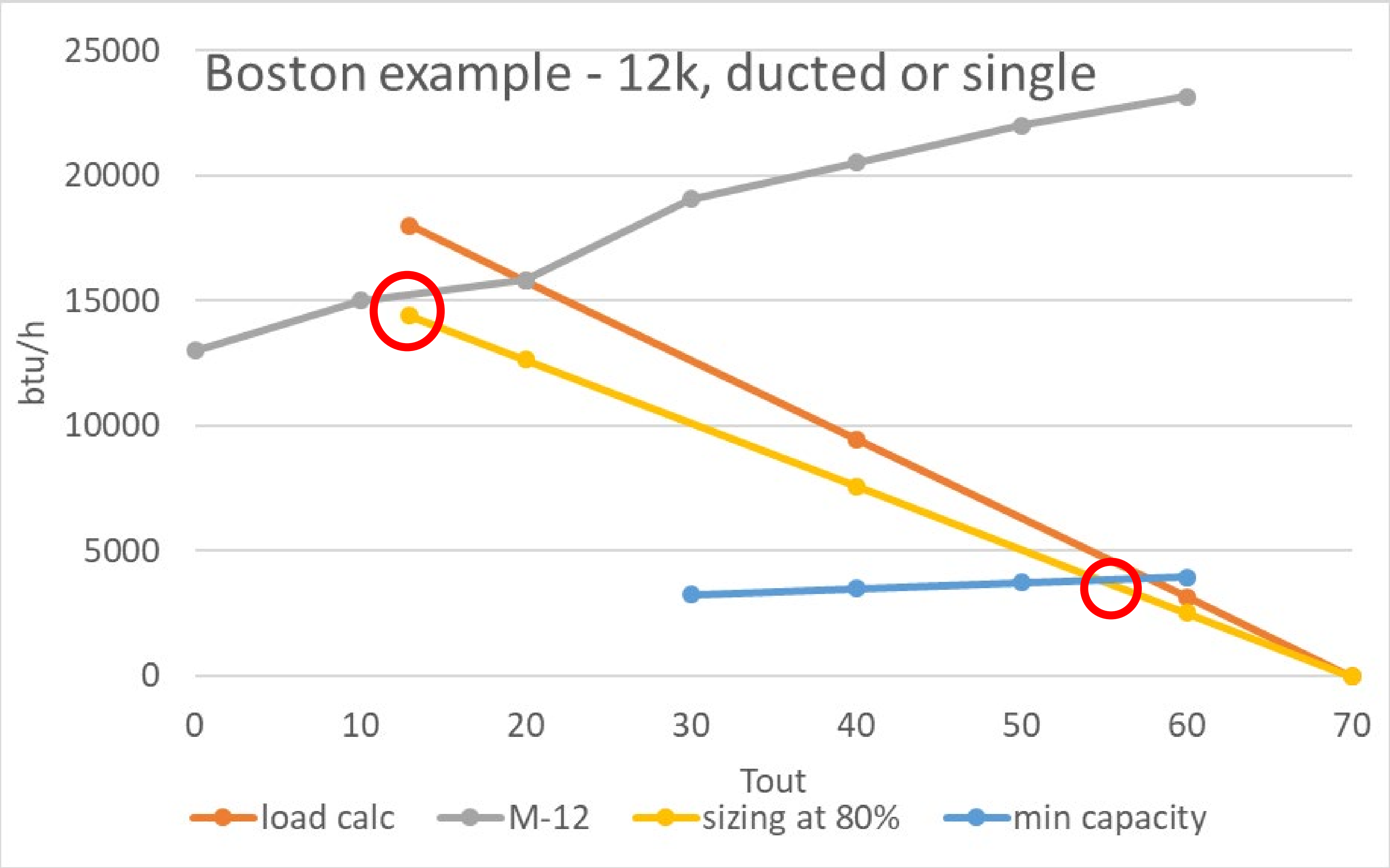


Until you see this:

- If the load is 20% high, unit will NEVER modulate
- Even if it's correct, modulates only below 20°F



12k 1-to-1 unit, 99% design temp



Important

When planning auxiliary heat

- Don't use enough to meet total heating load
  - If multiple outdoor units: only the difference, or up to the difference x 1.5 (eg 1.1 x 1.5 = 1.7 kW)
  - If only one outdoor unit: enough to keep house from freezing at design temp
- Include an easy way to turn it off
- Spread it out
  - 2-3 small heaters in distant areas, esp. w/ductless

Other sizing thoughts

- Smaller is better for efficiency
- More, smaller units better than fewer, larger
  - Similar cost; less risk of no-heat for service needs
- Turn-down is more critical at lower design temps
  - Bigger spread from design to low load conditions
  - Capacities drop off at lower temps
- Don’t completely trust manufacturer data or NEEP listings for low-speed specs

Specs reported to NEEP (e.g. 5C42):

6	Brand Name	Outdoor Unit Model	Minimum Capacity 47°F	Maximum Capacity 47°F	Minimum Capacity 17°F	Maximum Capacity 17°F	Minimum Capacity 5°F	Maximum Capacity 5°F
1180	Mitsubishi	MXZ-2C20NA2	7,400	25,500	12,500	15,500	10,500	11,100
1181	Mitsubishi	MXZ-4C36NAHZ	22,500	45,000	22,500	45,000	22,500	45,000
1182	Mitsubishi	MXZ-3C24NAHZ2	11,400	25,000	13,100	25,000	12,500	25,000
1183	Mitsubishi	MXZ-5C42NAHZ	24,000	48,000	24,000	48,000	24,000	48,000
1184	Mitsubishi	PUMY-P60NKMU1	19,526	66,000	14,121	65,000	9,809	57,000

Specs in submittal:

(For data on specific indoor units, see the MXZ-C Technical and Service Manual.)

Specifications			Model Name
Unit Type			MXZ-5C42NAHZ
Cooling* (Non-ducted / Ducted)	Rated Capacity	Btu/h	42,000 / 42,000
	Capacity Range	Btu/h	6,000 - 42,000
	Rated Total Input	W	3,130 / 3,890
Heating at 47°F* (Non-ducted / Ducted)	Rated Capacity	Btu/h	48,000 / 48,000
	Capacity Range	Btu/h	7,200 - 48,000
	Rated Total Input	W	3,430 / 4,350
	Rated Capacity	Btu/h	[illegible]

In Engineering Manual:

MXZ-5C42NAHZ

2) HEATING

Rated

Q(Btu/h): 48000

W: 3430

Indoor D.B.			80°F / 26.7°C						70°F / 21.1°C					
Outdoor W.B. (°F)	(°C)		Max.	Rated	75%	50%	25%	Min.	Max.	Rated	75%	50%	25%	Min.
47	8.3	Q(Btu/h)	37440	37440	28454	18346	-	11077	48000	48000	36480	23520	-	14201
		W	2830	2830	2264	1641	-	584	3087	3087	2470	1790	-	637

- Submittal is *not* based on outdoor unit
  - It's the smallest connectable *indoor* unit capacity
- ALWAYS look up engineering data *and* check that it makes sense!

NEEP Guides

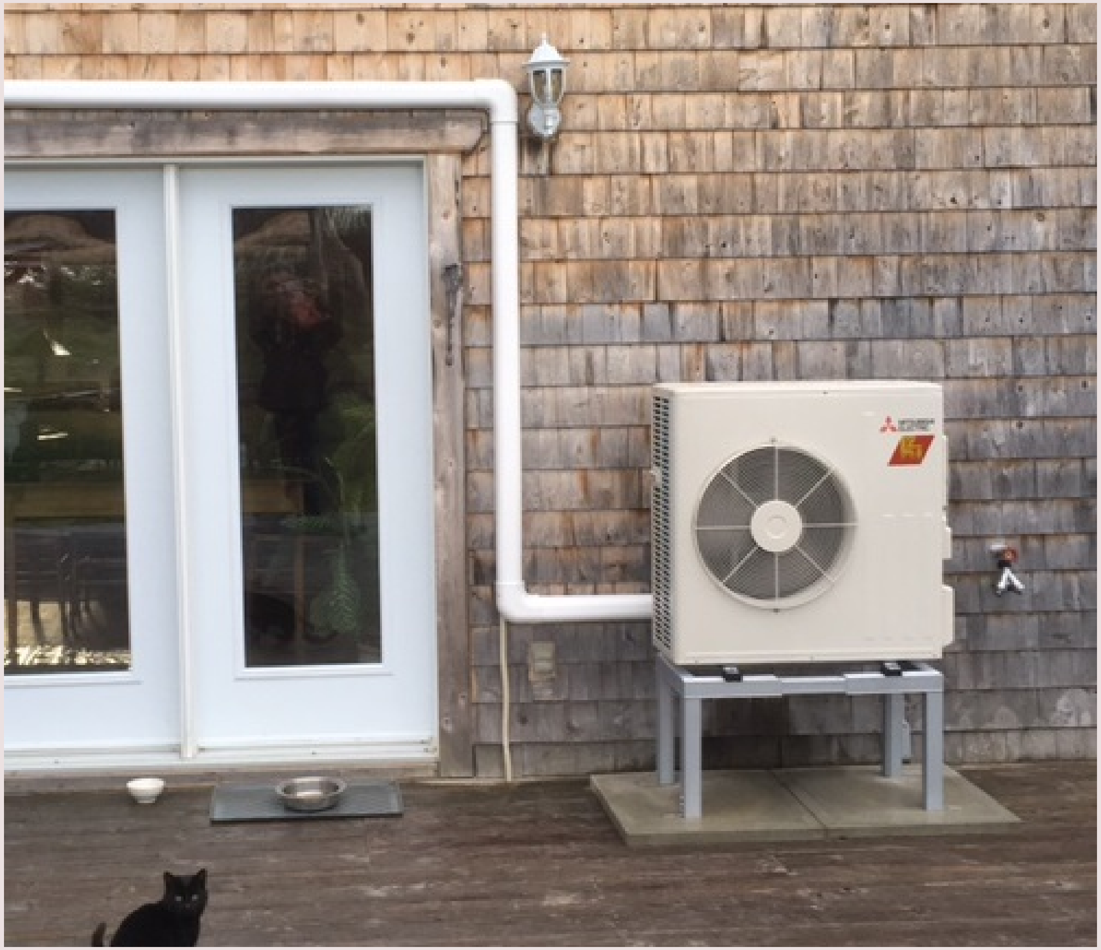
- Sizing/selection guide, and installation guide
- Videos
- Homeowner operation guide
- Cold climate model listings
  - Including 5°F and colder operation

neep.org/ASHPInstallerResources

Other Installation Issues

- Installation
  - Snow/ice / drip / drain pan heat etc
- Utilization (retrofit) – Integrated controls
- Follow manufacturers instructions carefully
  - Refrigerant charge adjustments if needed
  - Flare fittings – careful, or avoid (use crimp system)
  - Triple evacuation of refrigerant system; start-up process
- Keep above snow line – wall brackets
  - Best if mounted to foundation or on stand
- Surge protector at service disconnect

Wall mount or stand:



Beware frost heave w/stands

Drip Diverter

- Avoid eave drip, or use diverter
- Sheltering from above is good – don't obstruct air flow (follow instructions for clearances!)

Surge protector helps avoid this:

Thanks!

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