Control Systems: Design, Performance and Commissioning Issues

Set Points

Instructor:

David Sellers

Senior Engineer

Facility Dynamics Engineering

October 23, 2017

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Overview

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Set Points;
Figuring Out What you Want vs. What you Have

- The logic for a particular system configuration or piece of equipment may be very similar from:
  - System to system,
  - Central plant to central plant,
  - Location to location, and
  - Building to building

  But, the set points triggering different events in the logic will vary significantly from:
  - Location to location
  - Load requirement to load requirement, and
  - Equipment selection to equipment selection …

… Even though the same control logic may be applied to the situation

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Are They Appropriate for the Climate?

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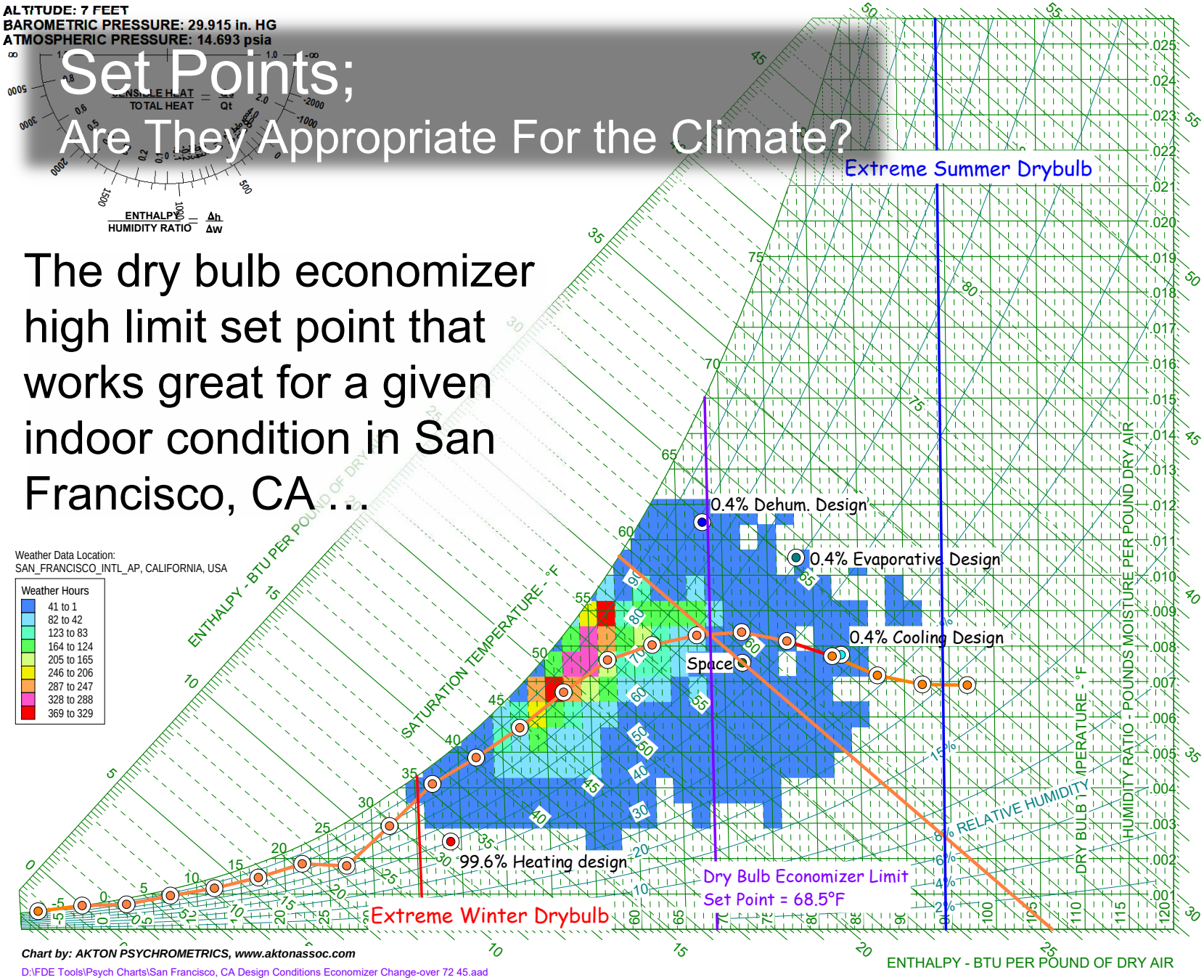
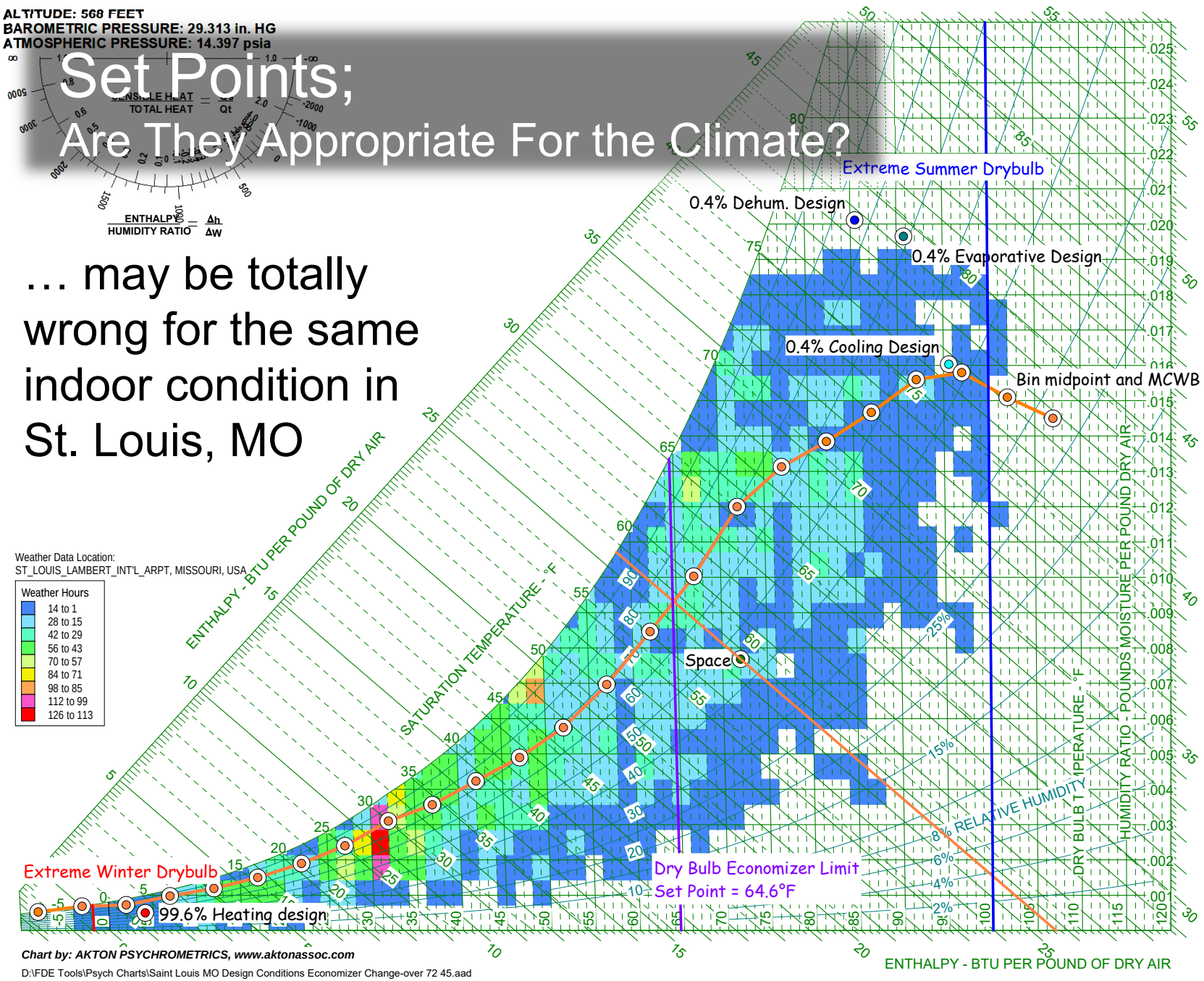
Set Points;
Are They Appropriate For the Climate?

The dry bulb economizer high limit set point that works great for a given indoor condition in San Francisco, CA…



Set Points;
Are They Appropriate For the Climate?

… may be totally wrong for the same indoor condition in St. Louis, MO



More on Dry Bulb Economizer Limit Set Points

- *Why Enthalpy Economizers Don't Work*, by Steve Taylor, available at: http://tinyurl.com/SteveTaylorEconomizerLimit
- *Functional Testing Guide Chapter 3 - Economizer and Mixed Air*, available at http://www.ftguide.org/ftg/

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Are They Appropriate for the Load?

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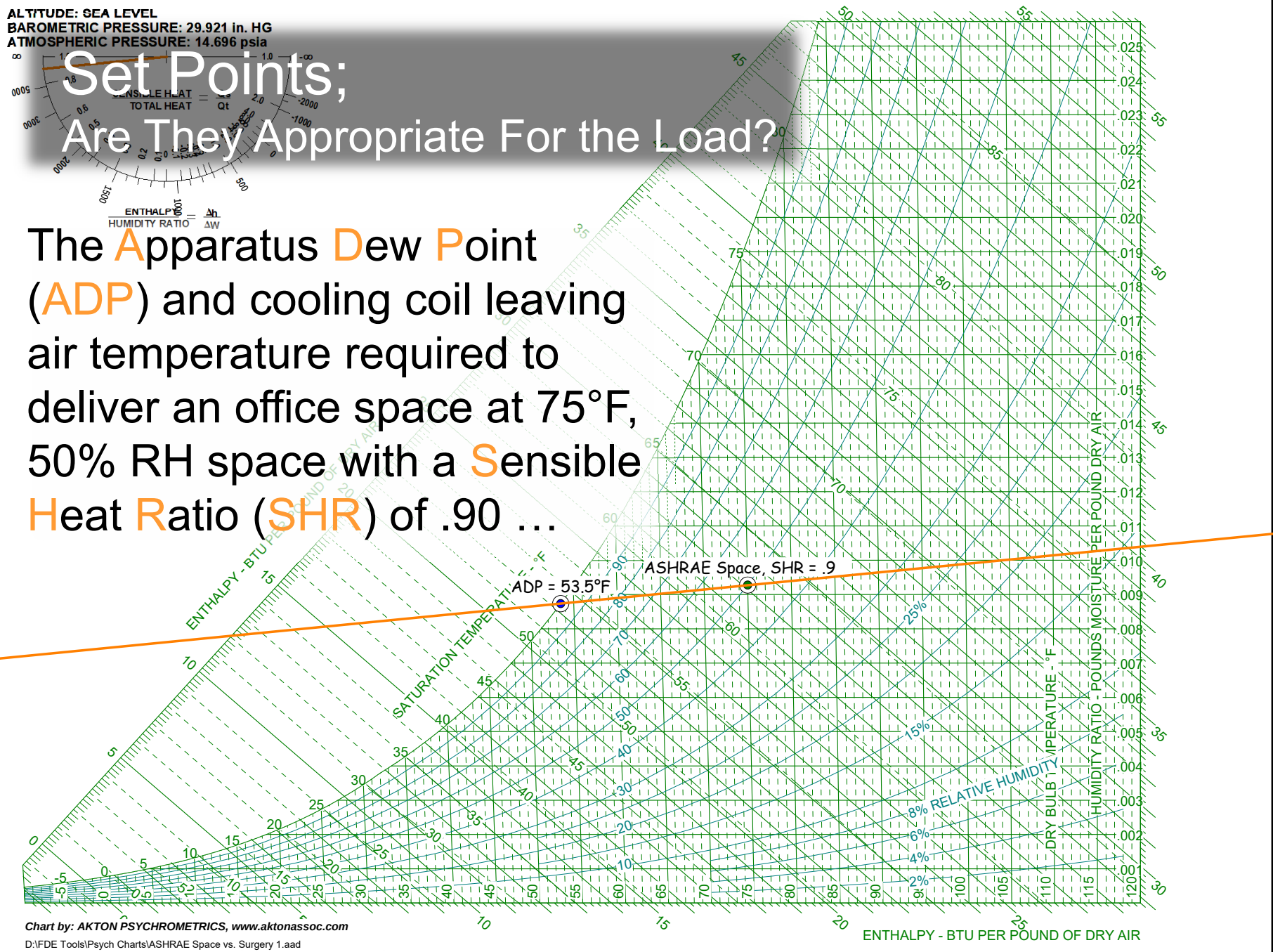
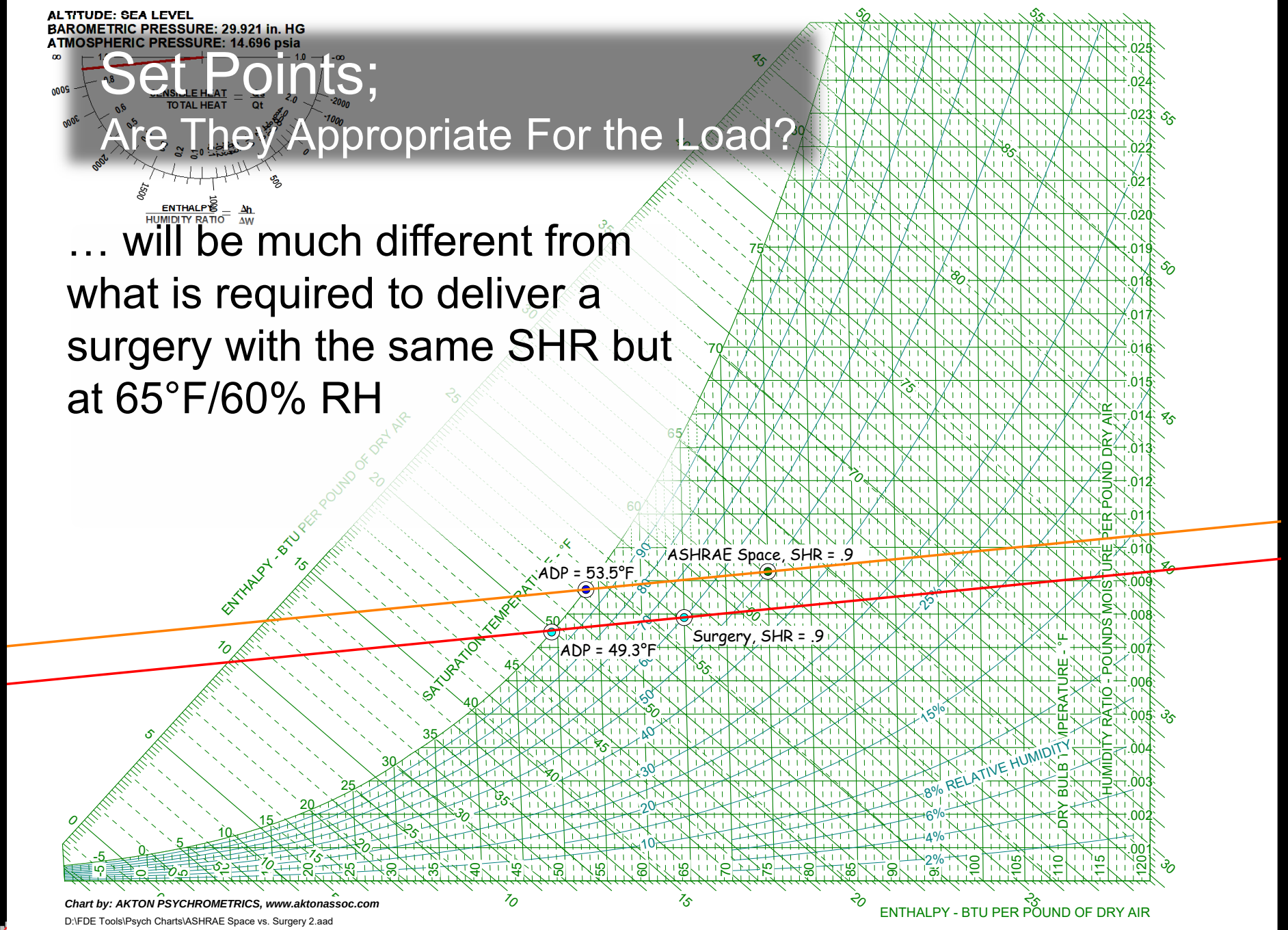
Set Points;
Are They Appropriate For the Load?

The Apparatus Dew Point (ADP) and cooling coil leaving air temperature required to deliver an office space at 75°F, 50% RH space with a Sensible Heat Ratio (SHR) of .90 …



Set Points;
Are They Appropriate For the Load?

… will be much different from what is required to deliver a surgery with the same SHR but at 65°F/60% RH



Set Points;

Set Point Reset; Not 1 Size Fits All?

- In the San Francisco Bay area, it is not uncommon to see Air Handling Unit (AHU) Leaving Air Temperature (LAT) reset schedules that reset the LAT to 65°F (or higher) under low load conditions
- The same reset schedule may be a really bad idea in hot and humid climates like St. Louis, Missouri or Honolulu Hawaii

Consider this "Vanilla" System in St. Louis, MO

At Design Conditions

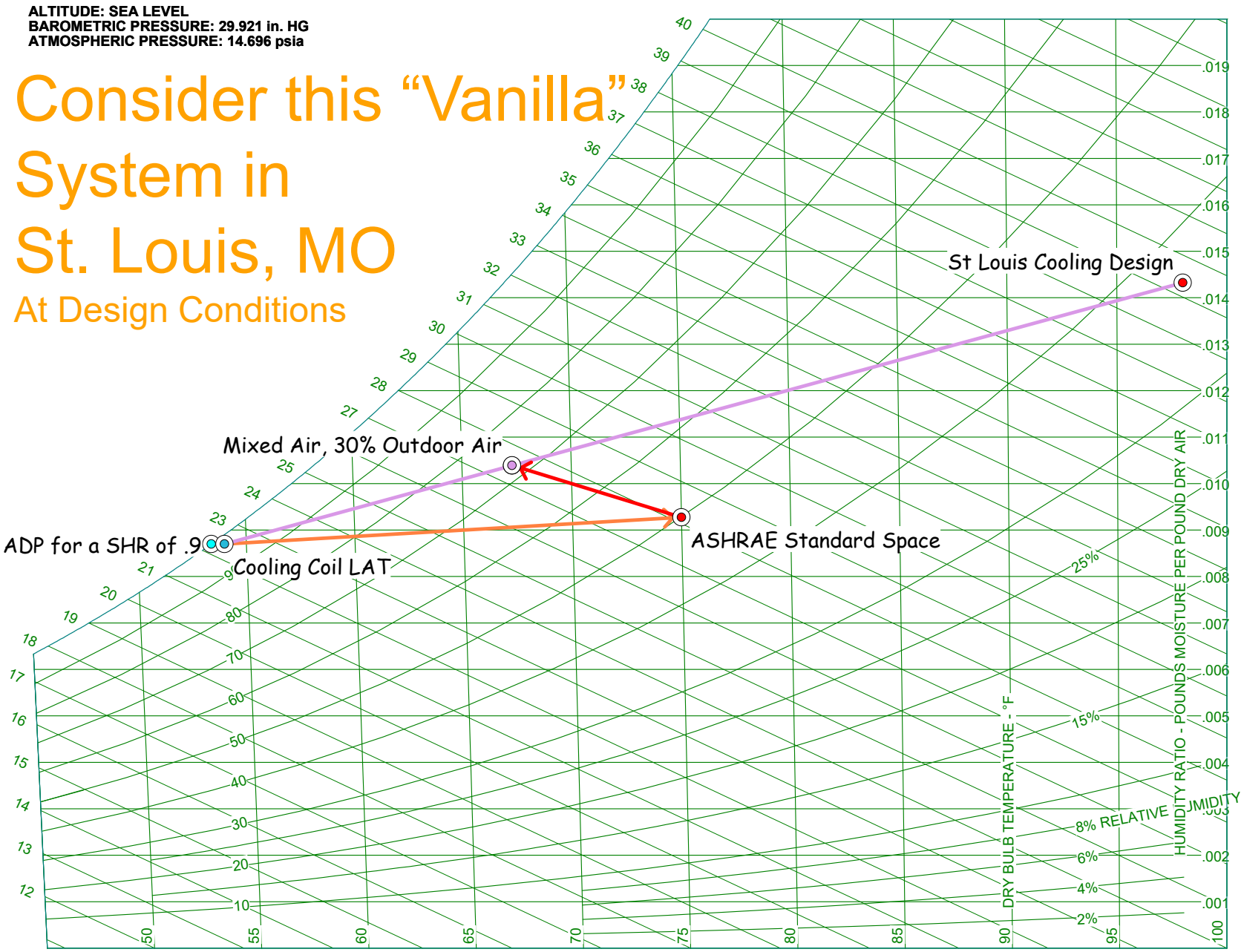


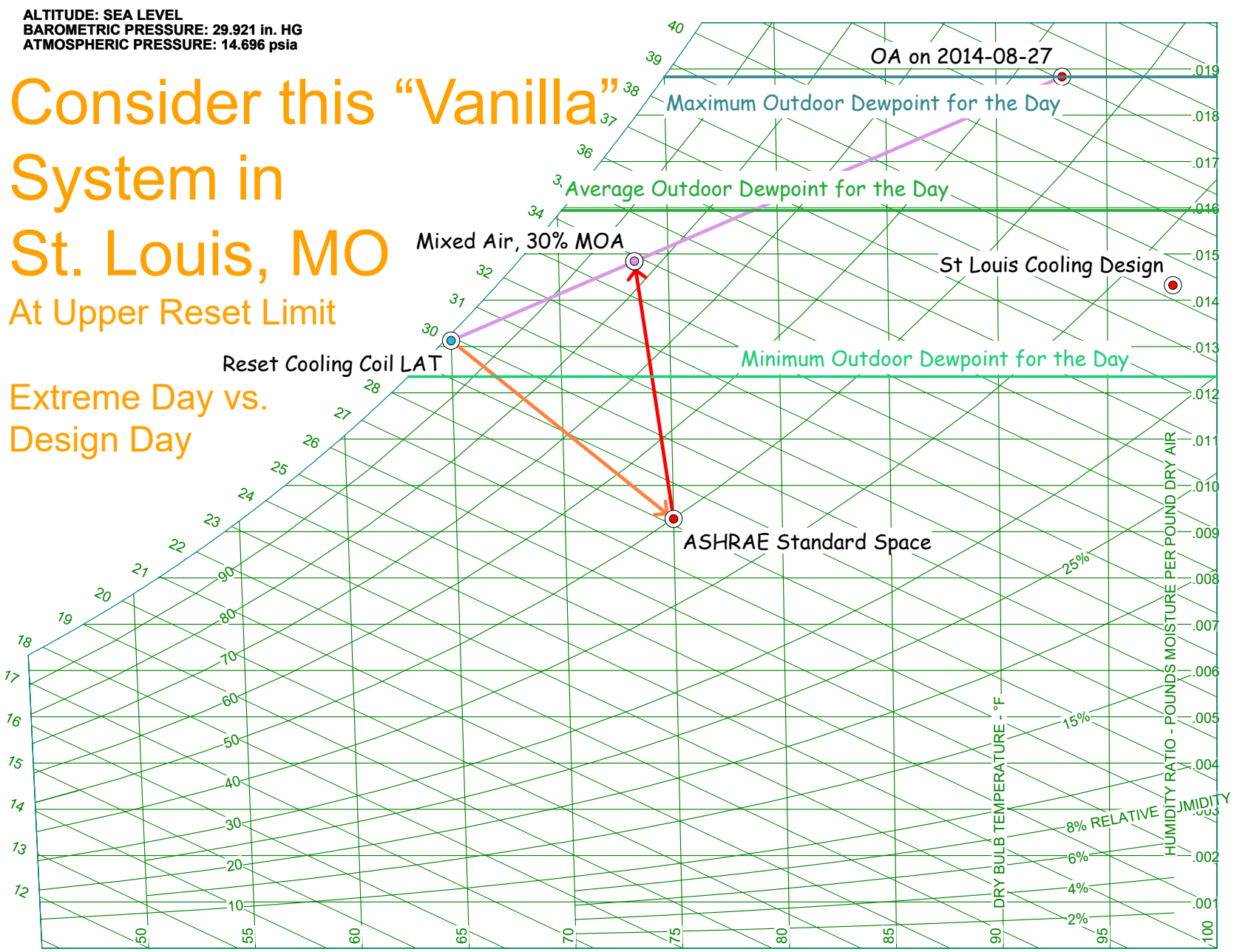
Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com

C:\Users\DSellers\Documents\FDE Tools\SketchUp\Marriott Ballroom AHU\Design Info Anahiem Marriott Basis\St. Louis 2014-08-27 - Design Cycle.aad

Consider this "Vanilla" System in St. Louis, MO

At Upper Reset Limit

Extreme Day vs. Design Day



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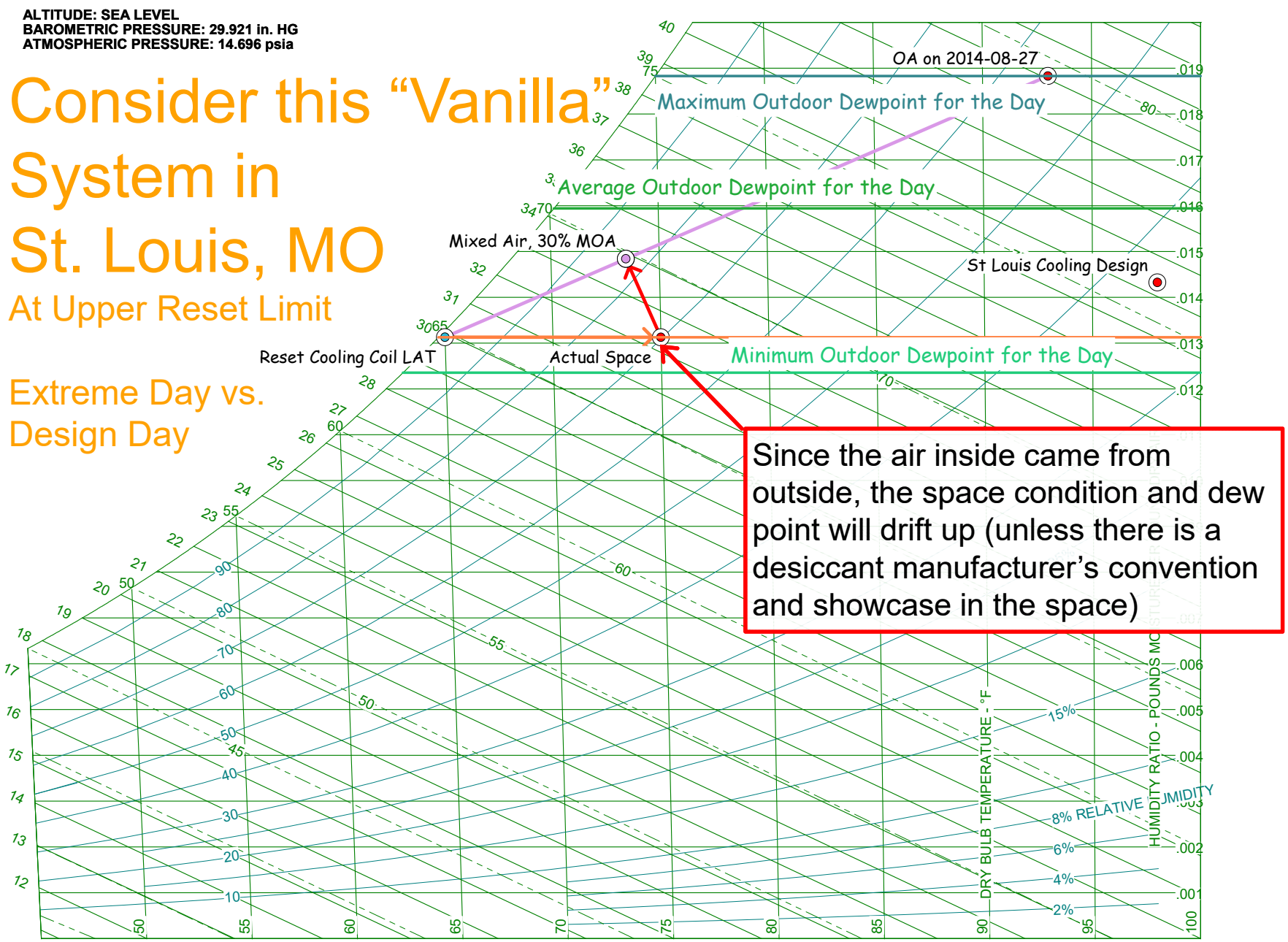
Consider this "Vanilla" System in St. Louis, MO

At Upper Reset Limit

Extreme Day vs. Design Day



Since the air inside came from outside, the space condition and dew point will drift up (unless there is a desiccant manufacturer's convention and showcase in the space)

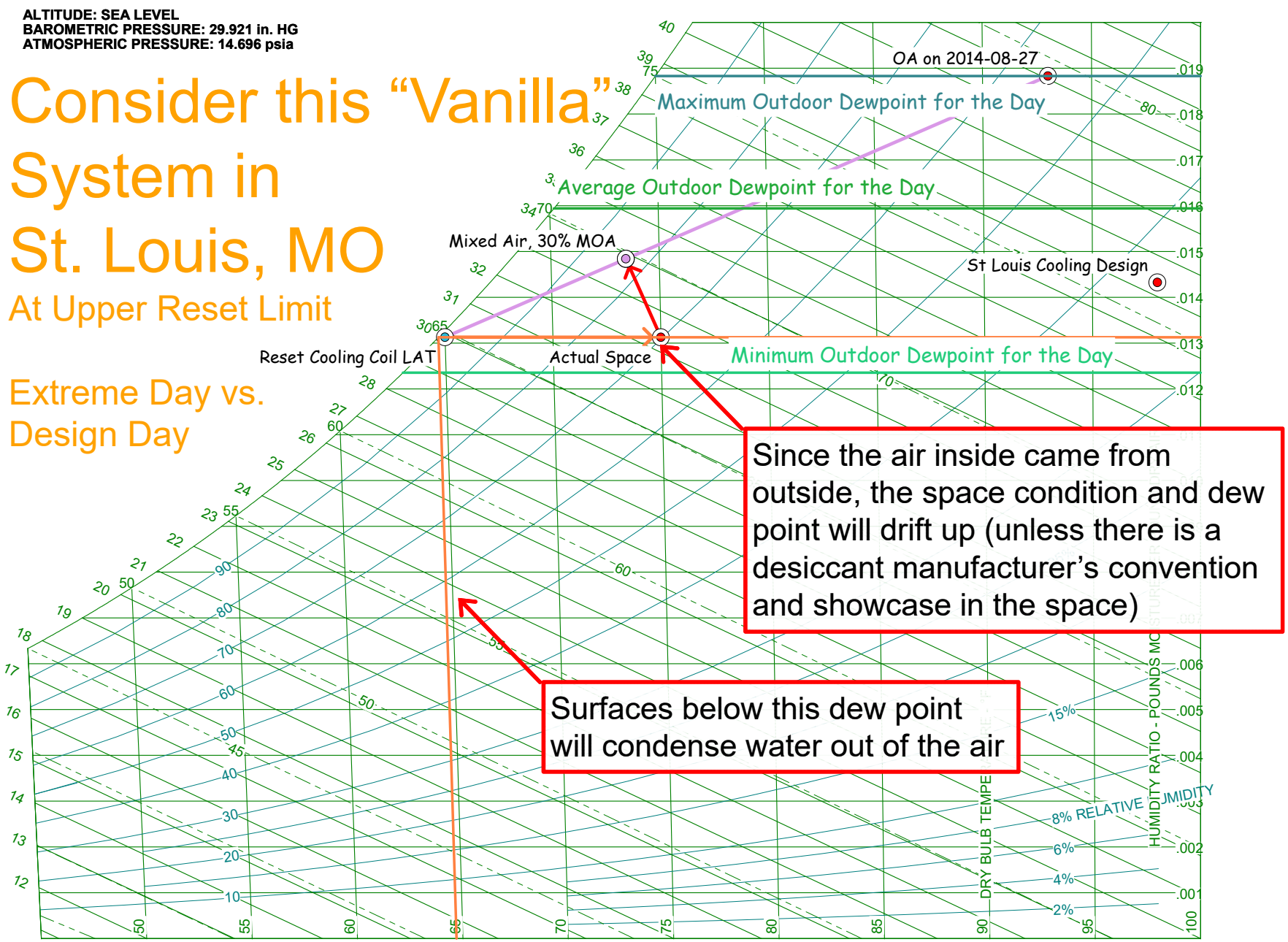
Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com

D:\FDE Tools\SketchUp\Marriott Ballroom AHU\Design Info Anahiem Marriott Basis\St. Louis 2014-08-27 - Reset Up - Dew Point.aad

Consider this "Vanilla" System in St. Louis, MO

At Upper Reset Limit

Extreme Day vs. Design Day



Since the air inside came from outside, the space condition and dew point will drift up (unless there is a desiccant manufacturer's convention and showcase in the space)

Surfaces below this dew point will condense water out of the air

Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com

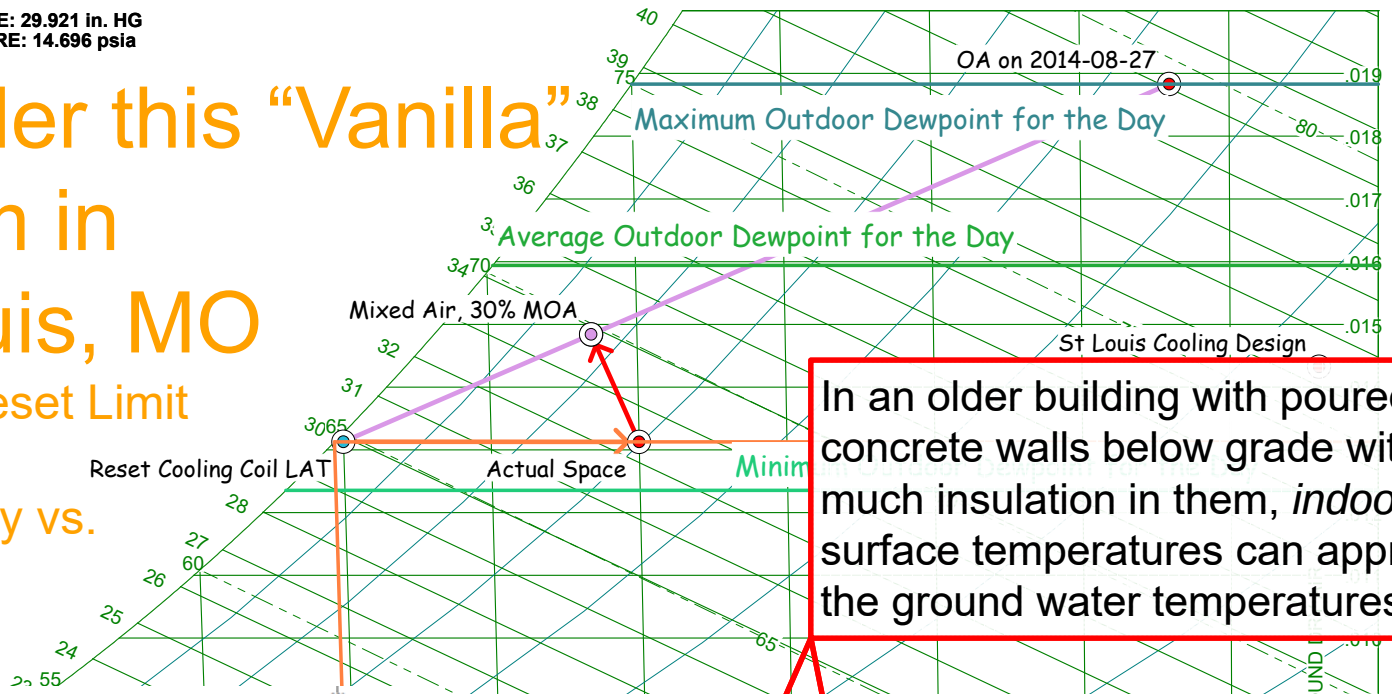
D:\FDE Tools\SketchUp\Marriott Ballroom AHU\Design Info Anahiem Marriott Basis\St. Louis 2014-08-27 - Reset Up - Dew Point.aad

ALTITUDE: SEA LEVEL
BAROMETRIC PRESSURE: 29.921 in. HG
ATMOSPHERIC PRESSURE: 14.696 psia

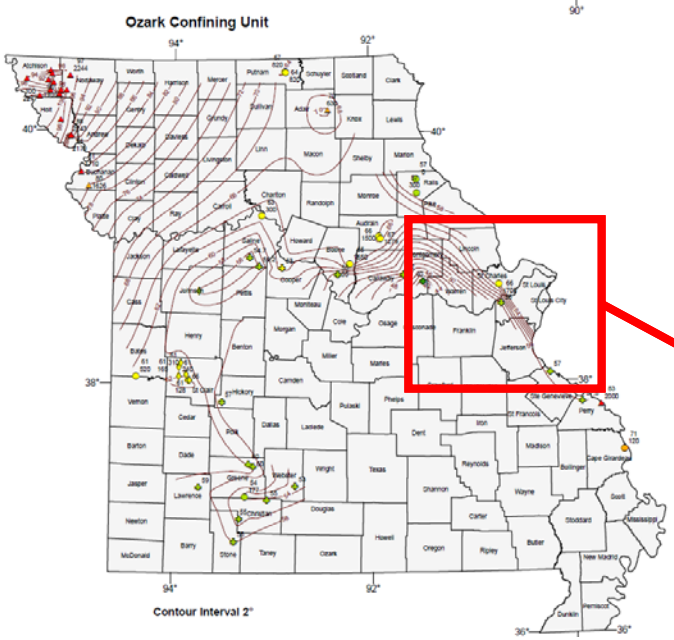
Consider this "Vanilla" System in St. Louis, MO

At Upper Reset Limit

Extreme Day vs. Design Day



In an older building with poured concrete walls below grade without much insulation in them, *indoor* surface temperatures can approach the ground water temperatures



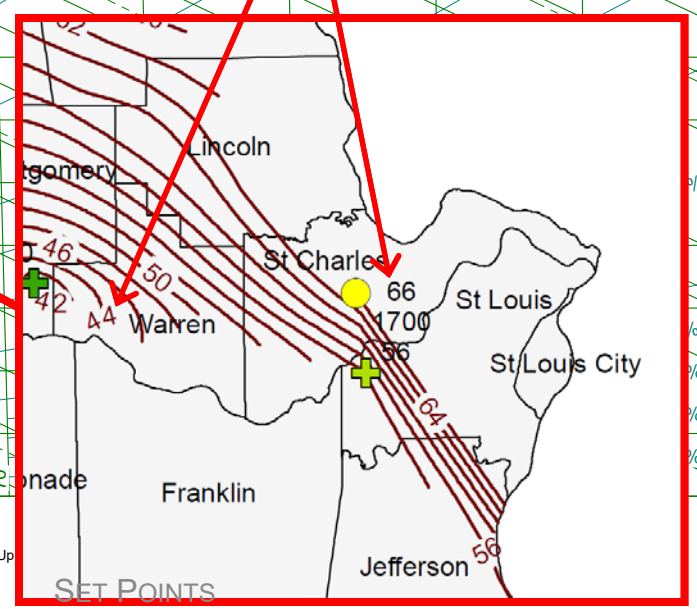
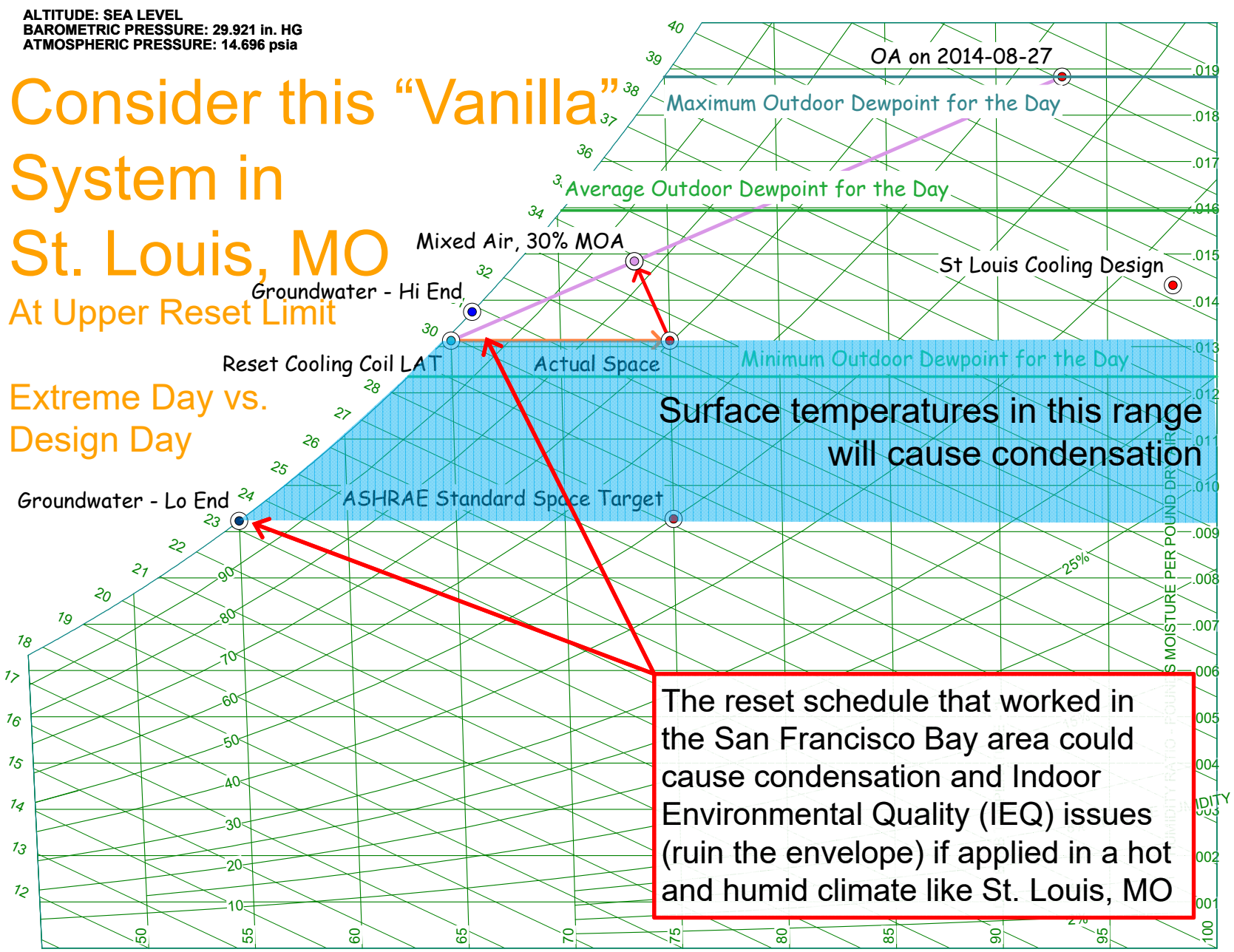


Image courtesy of http://repository.stategeothermaldata.org/repository/

Consider this "Vanilla" System in St. Louis, MO

At Upper Reset Limit

Extreme Day vs. Design Day



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Set Points

Are They Appropriate for the Equipment Selections?

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Set Points;

Are They Appropriate for the Equipment Selection?

Two Cooling Towers Selected for the Same Load Requirement

- Best first cost tower
  - 60 bhp
  - 69.5 gpm/hp
  - $7,230 per year for fan energy
- Best life cycle cost tower
  - 40 bhp
  - 105.8 gpm/hp
  - $4,810 per year for fan energy
  - Fan energy savings = $2,420 per year

UPDATE™ Version 5.2.0
Product Data: 11/14/2016 (Current)

© 2016 SPX Cooling Technologies, Inc.
11/26/2016 12:54:44 PM

Job Information

Region	North America
Product Type	Cooling Towers
Electrical Source	60 Hz
Labor Rate	50 USD/h

Selected By

Facility Dynamics Engineering
NW Satellite Office
8560 North Buchanan Avenue
DSellers@FacilityDynamics.com
David Sellers
Tel 503-286-1494

SPX Cooling Technologies Contact

TraneOregon
7257 SW Kable Lane
Portland, OR
ddriver@trane.com
Tel 503-620-8031

Design Conditions

Solve For	Capacity
Tolerance Under Design	5 %
Number of Cells	2
Tower Water Flow	3450 gpm
Hot Water Temperature	86 °F
Cold Water Temperature	76 °F
Total Heat Load	17216000 Btu/h
Wet-Bulb Temperature	66 °F

Evaluation Parameters

Energy Cost	0.08 $/kWh
Annual Operating Time	2000 h
Evaluation Period	1 years
Interest Rate	10 %
Cold Water Set Point	76 °F
Average Wet-Bulb	66 °F
Range at Avg. Wet-Bulb	10 °F
Maximum Wet-Bulb	66 °F
Wet-Bulb Profile	Linear
Fan Operation	Single-Speed
Motor Efficiency	90 %

Advanced

Sound Requirements

Calculation	Single Cell
Location	Air Inlet
Distance from Product	5 ft
Maximum SPL	NA

Product
NC Steel

Sound Location
Air Inlet Face

Selections

Model	Cells	Status	Fan Motor Output BHp	Total Fan Motor Output BHp	Capacity	Cost Ratio	ASHRAE 90.1 Perf. gpm/Hp	Fan Energy Cost $	Pump Energy Cost $	dBA Single Cell
NC8405UAN2	2	Caution	50.0	100.0	99.2%	0.92	41.5	12050	1667	84
NC8405ULN2	2	Caution	50.0	100.0	97.9%	0.92	41.0	12050	1667	82
NC8405TAS2	2	Caution	40.0	80.0	99.0%	1.00	51.7	9640	1667	84
NC8405UAS2	2	CTI	50.0	100.0	103.5%	1.00	43.2	12010	1667	84
NC8405TLS2	2	Caution	40.0	80.0	97.2%	1.00	50.9	9640	1667	81
NC8405ULS2	2	CTI	50.0	100.0	102.3%	1.01	42.7	12020	1667	82
NC8407SAN2	2	CTI	30.0	60.0	100.0%	1.03	70.2	7230	1667	81
NC8407SLN2	2	Caution	30.0	60.0	99.3%	1.04	69.5	7230	1667	78
NC8407TAN2	2	CTI	40.0	80.0	109.2%	1.04	57.3	9520	1667	83
NC8407UAN2	2	CTI	50.0	100.0	117.4%	1.05	49.2	11790	1667	85
NC8407TLN2	2	CTI	40.0	80.0	105.3%	1.06	55.3	9570	1667	80
NC8407ULN2	2	CTI	50.0	100.0	115.6%	1.06	48.4	11810	1667	83
NC8407VAN2	2	CTI	60.0	120.0	123.1%	1.10	42.9	14070	1667	86
NC8407RAS2	2	Caution	25.0	50.0	98.8%	1.11	83.1	6030	1667	80
NC8407VLN2	2	CTI	60.0	120.0	121.2%	1.11	42.2	14090	1667	84
NC8407SAS2	2	CTI	30.0	60.0	104.8%	1.11	73.4	7180	1667	81
NC8407RLS2	2	Caution	25.0	50.0	97.4%	1.12	81.9	6030	1667	75
NC8407SLS2	2	CTI	30.0	60.0	106.0%	1.12	74.0	7170	1667	78
NC8407TAS2	2	CTI	40.0	80.0	114.2%	1.13	59.8	9470	1667	83
NC8409QAN2	2	CTI	20.0	40.0	100.7%	1.13	105.8	4810	1667	74

Set Points;

Are They Appropriate for the Equipment Selection?

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  - $7,230 per year for fan energy
- Best life cycle cost tower
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  - 105.8 gpm/hp
  - $4,810 per year for fan energy
  - Fan energy savings = $2,420 per year

Its likely that capturing the energy savings will require different set points for control processes related to the cooling tower fan operation

Set Points;

Are They Appropriate for the Equipment Selection?

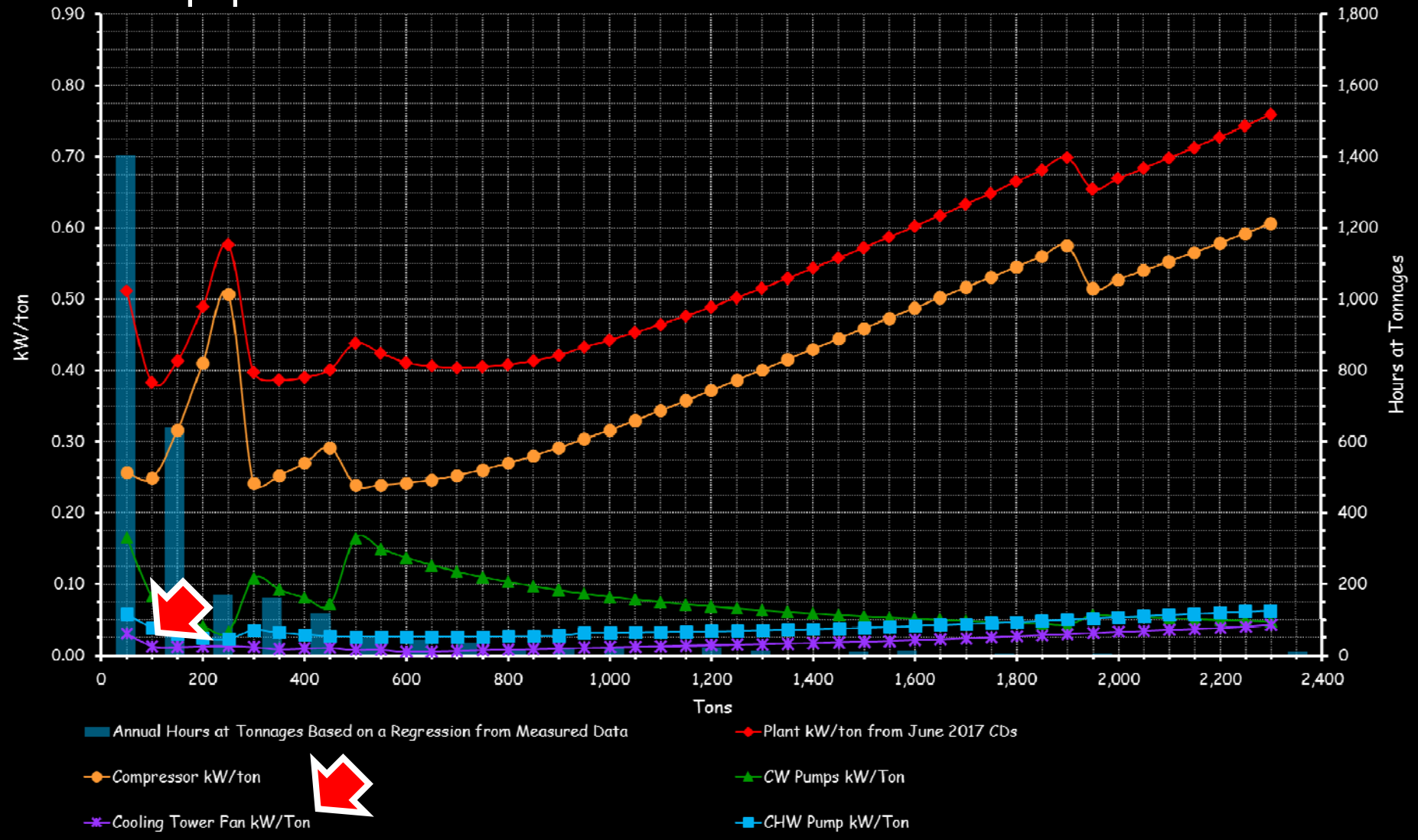
Consider a variable flow, primary only chilled water plant

- 1 – 300 ton chiller
- 2 – 1,000 ton chillers
- Induced draft cooling towers
- Best first cost equipment selections

Set Points;

Are They Appropriate for the Equipment Selection?

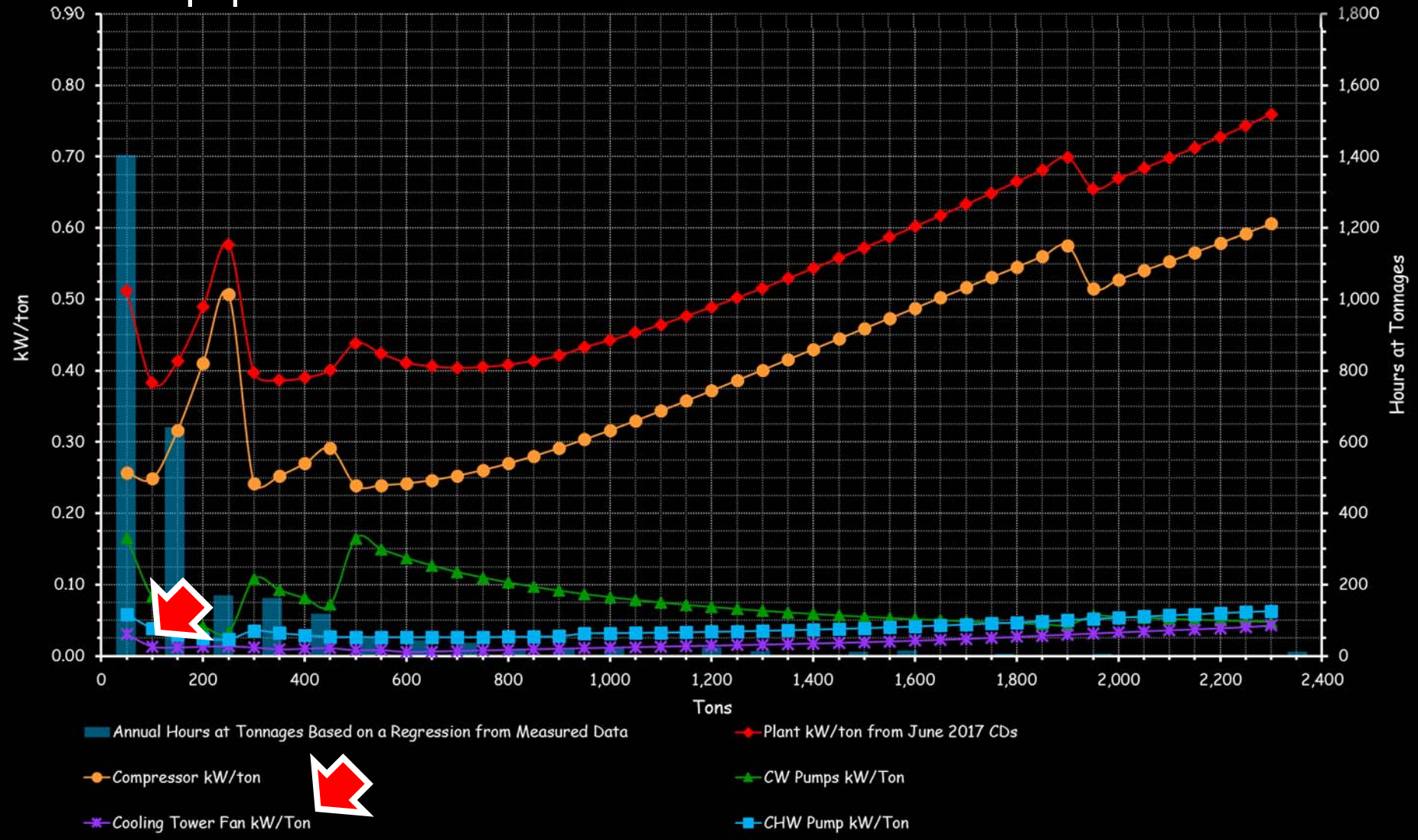
Cooling tower fan energy is only one (relatively small) component of the over-all plant kW/ton



Set Points;

Are They Appropriate for the Equipment Selection?

Changing the induced draft towers could increase the cooling tower component for kW/ton by a factor of 2-3 or more …



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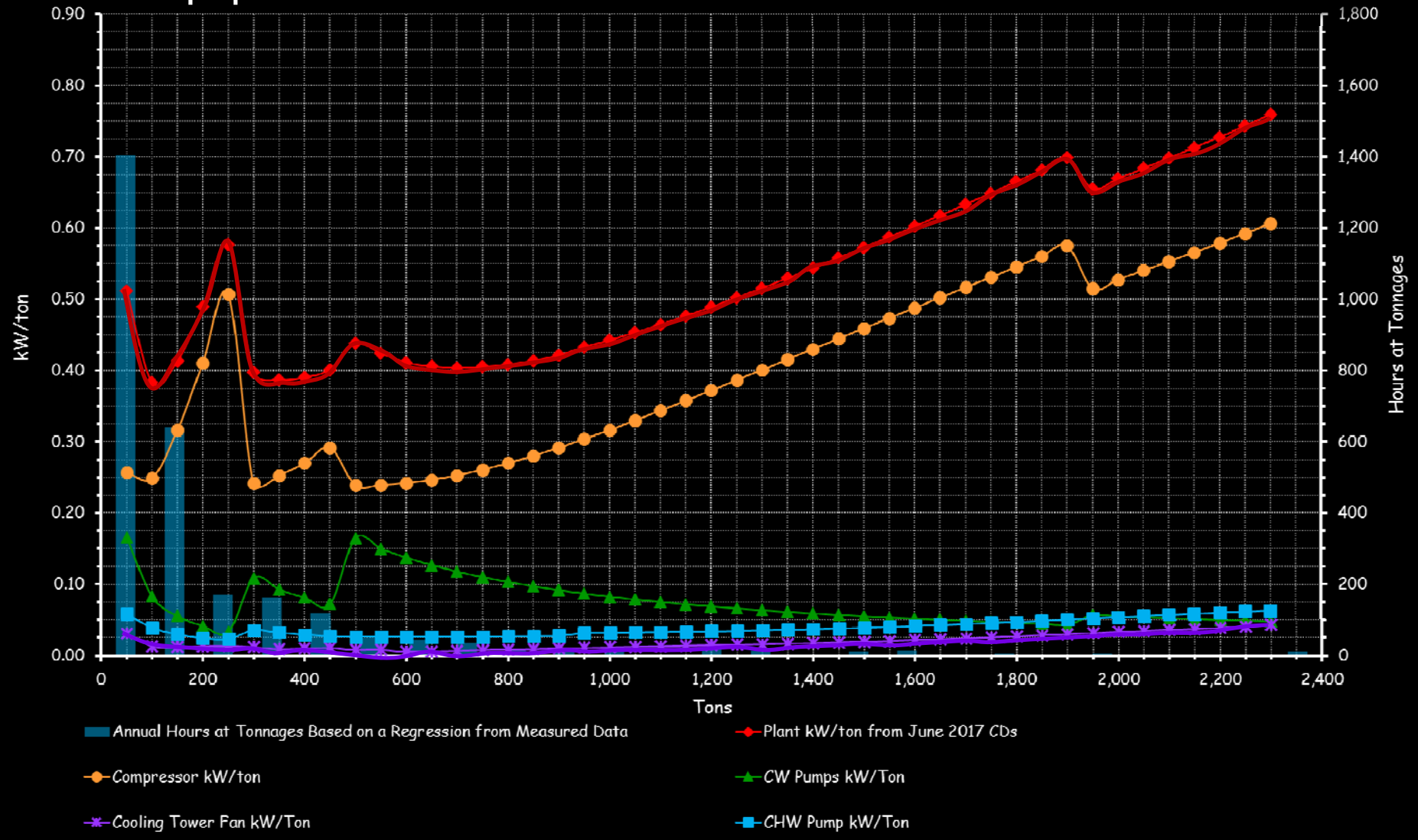
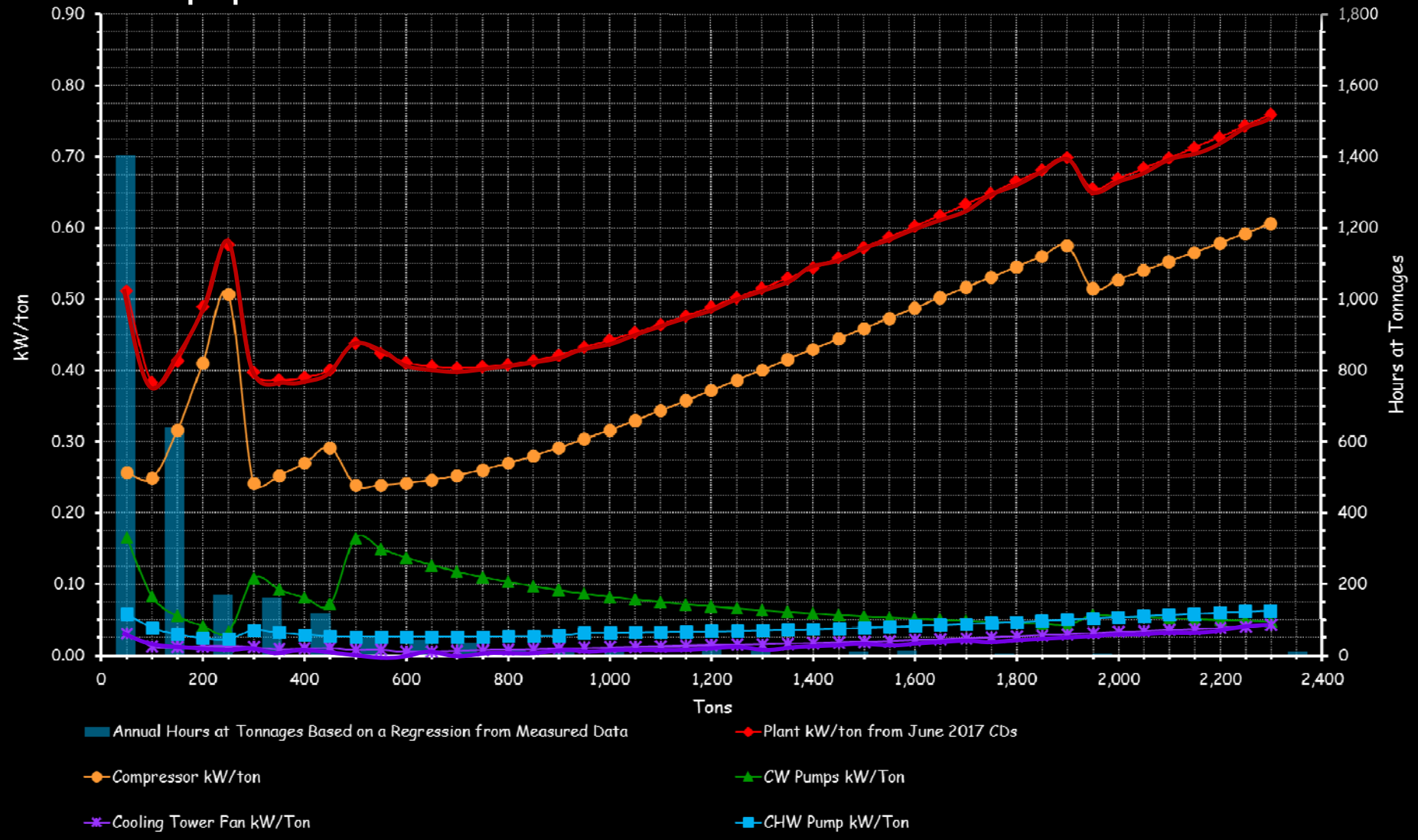


Set Points;

Are They Appropriate for the Equipment Selection?

As a result, the logic and set points used to stage the fans might be different for the same plant served by induced draft towers

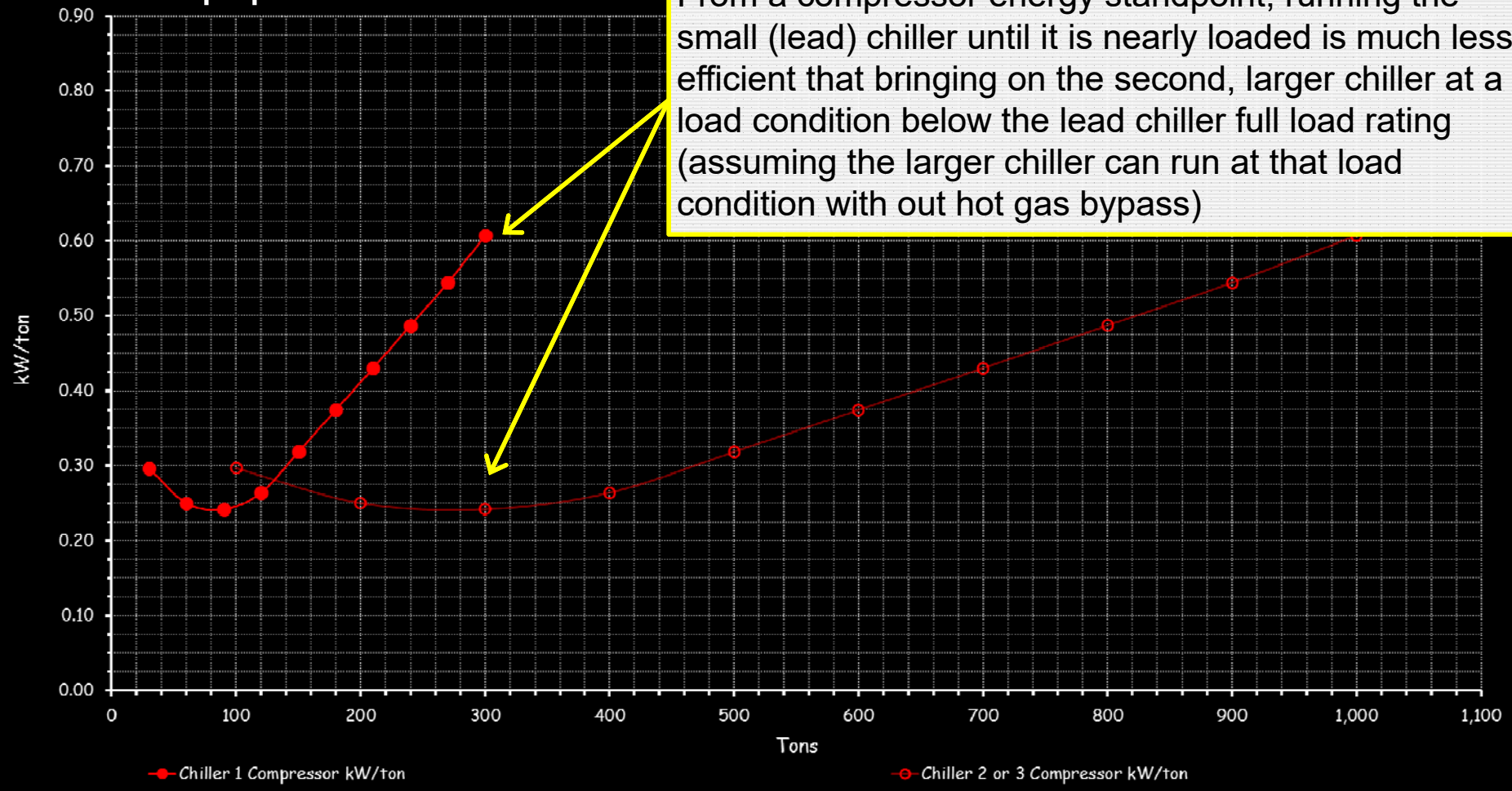


Set Points;

Are They Appropriate for the Equipment Selection?

Chiller compressor energy is very specific to the machine …

From a compressor energy standpoint, running the small (lead) chiller until it is nearly loaded is much less efficient that bringing on the second, larger chiller at a load condition below the lead chiller full load rating (assuming the larger chiller can run at that load condition with out hot gas bypass)

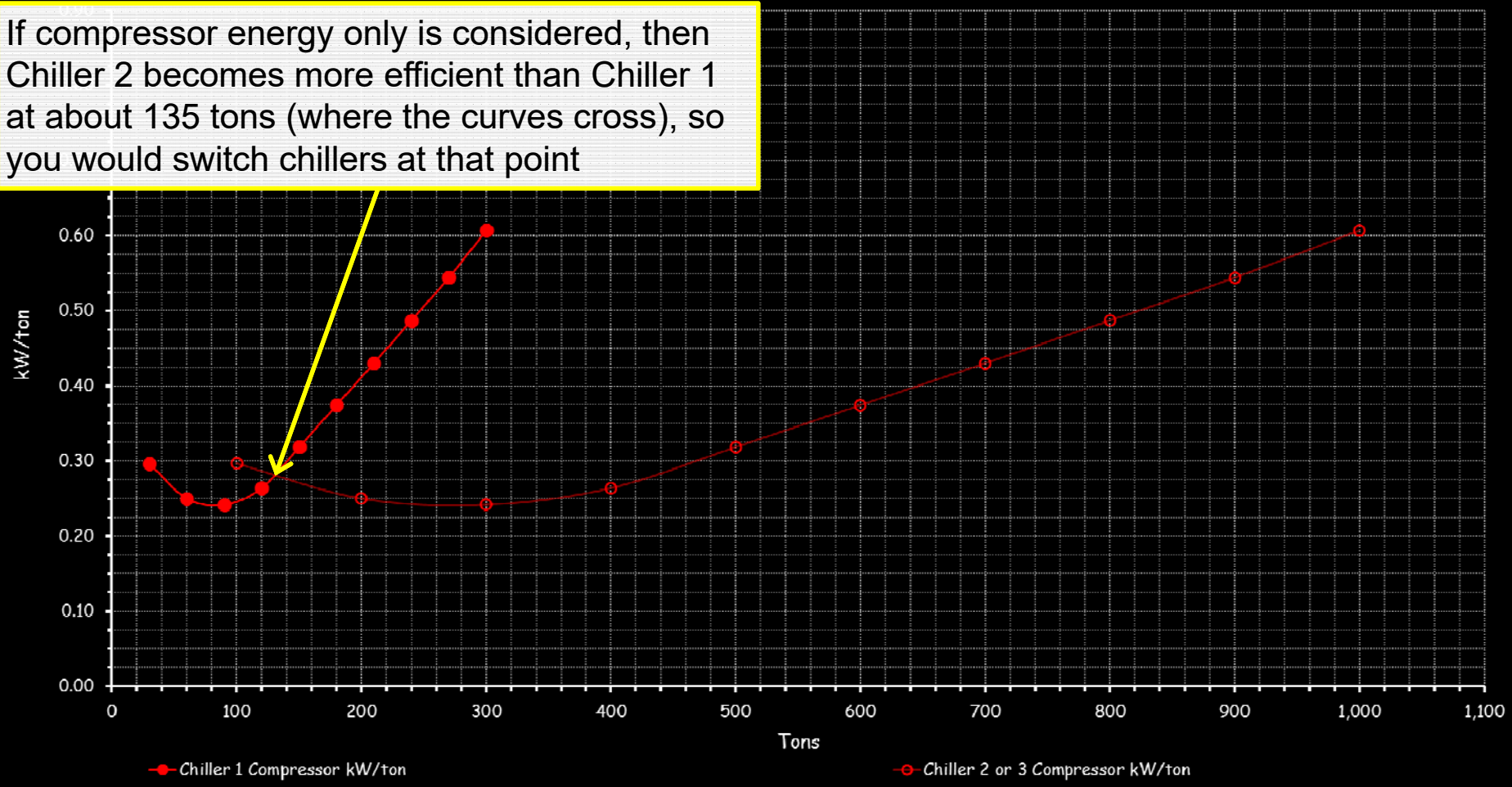


Set Points;

Are They Appropriate for the Equipment Selection?

Chiller compressor energy is very specific to the machine …

If compressor energy only is considered, then Chiller 2 becomes more efficient than Chiller 1 at about 135 tons (where the curves cross), so you would switch chillers at that point



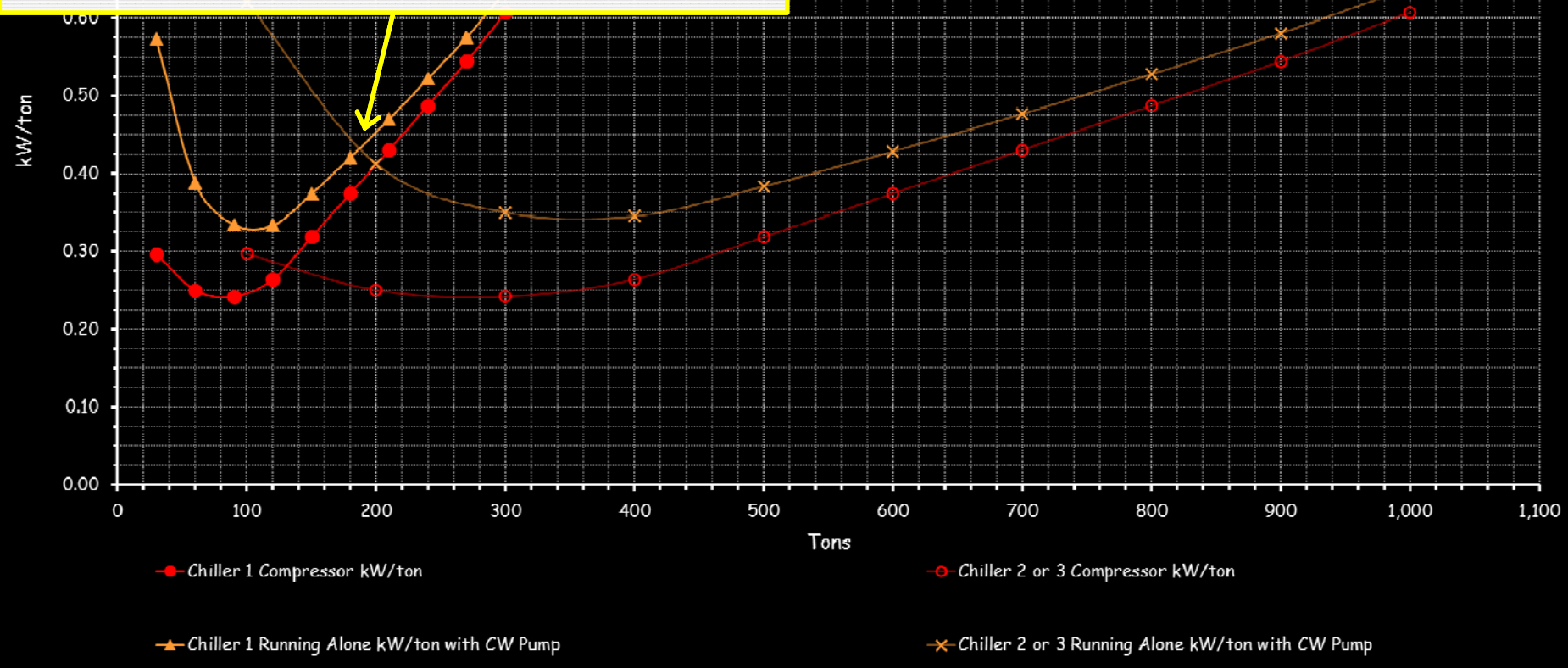
Set Points;

Are They Appropriate for the Equipment Selection?

Chiller compressor energy is very specific to the machine …

and condenser pump energy is very specific to the pump and its operating point

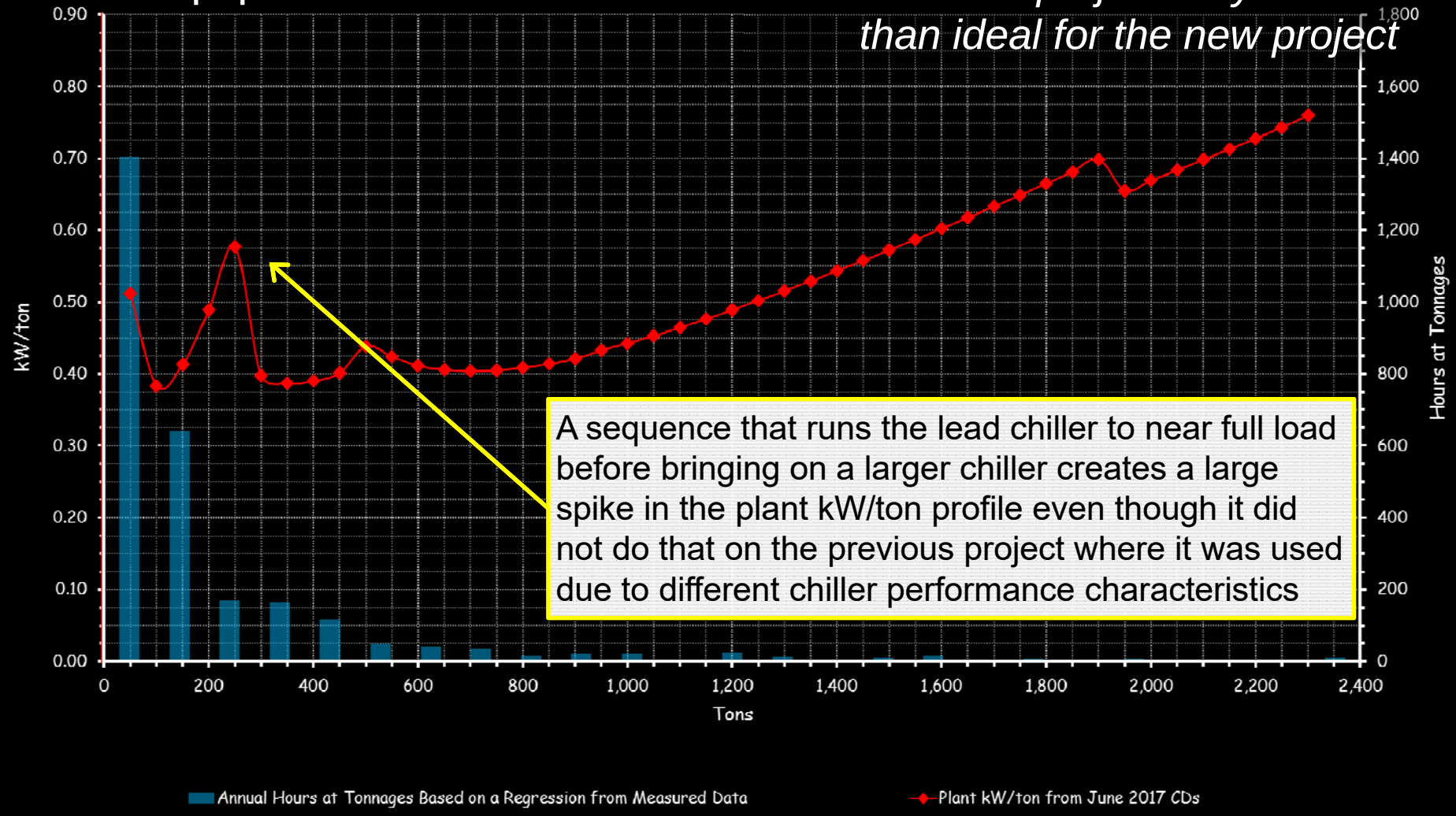
If condenser pump energy is considered (the second most significant component for the *plant* kW/ton) in addition to chiller energy, then the staging point for switching chillers is more like 183 tons



Set Points;

Are They Appropriate for the Equipment Selection?

Chiller staging set points that were ideal for a plant with a different mix of chiller tonnages from the last project may be less than ideal for the new project

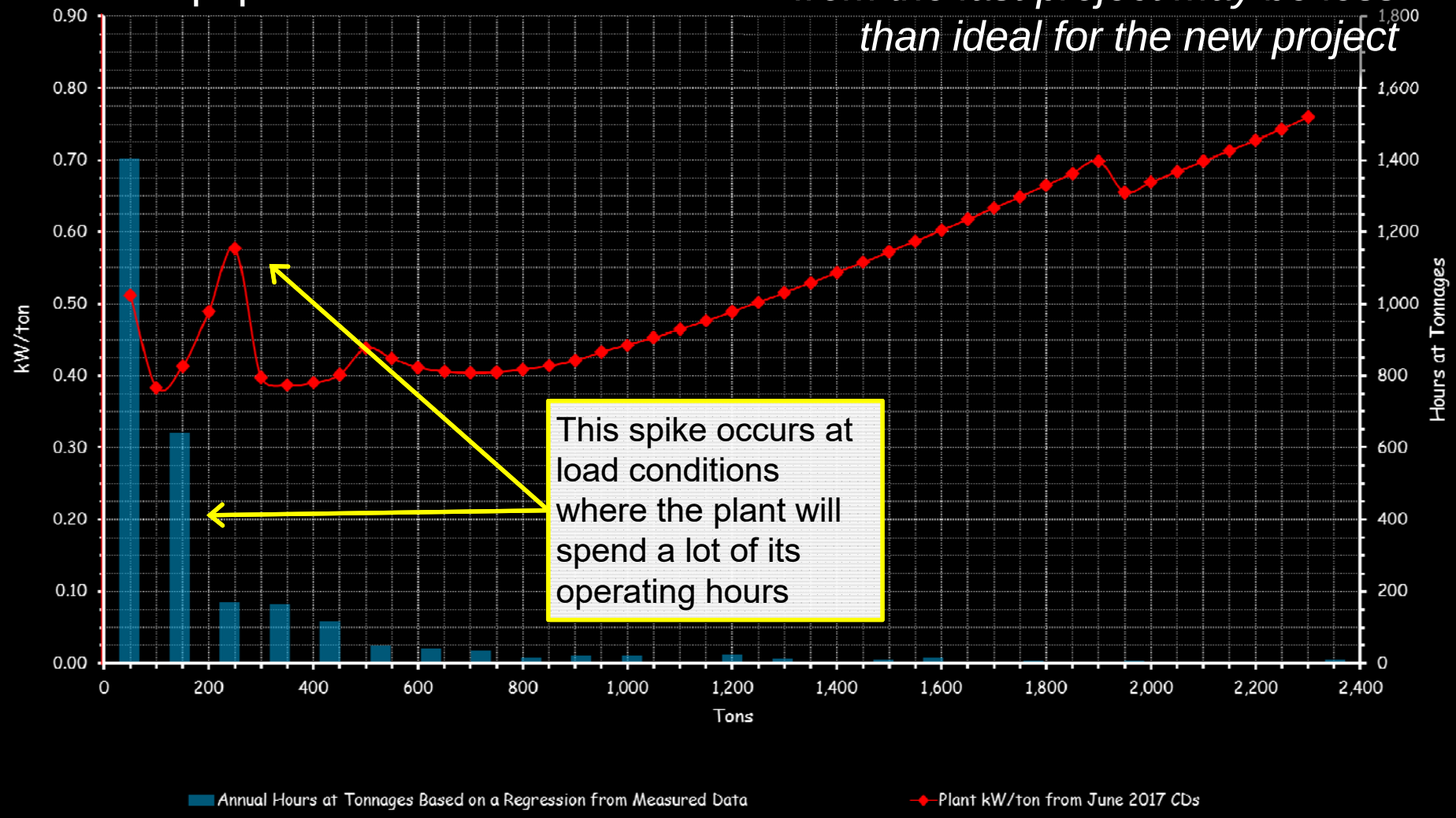


A sequence that runs the lead chiller to near full load before bringing on a larger chiller creates a large spike in the plant kW/ton profile even though it did not do that on the previous project where it was used due to different chiller performance characteristics

Set Points;

Are They Appropriate for the Equipment Selection?

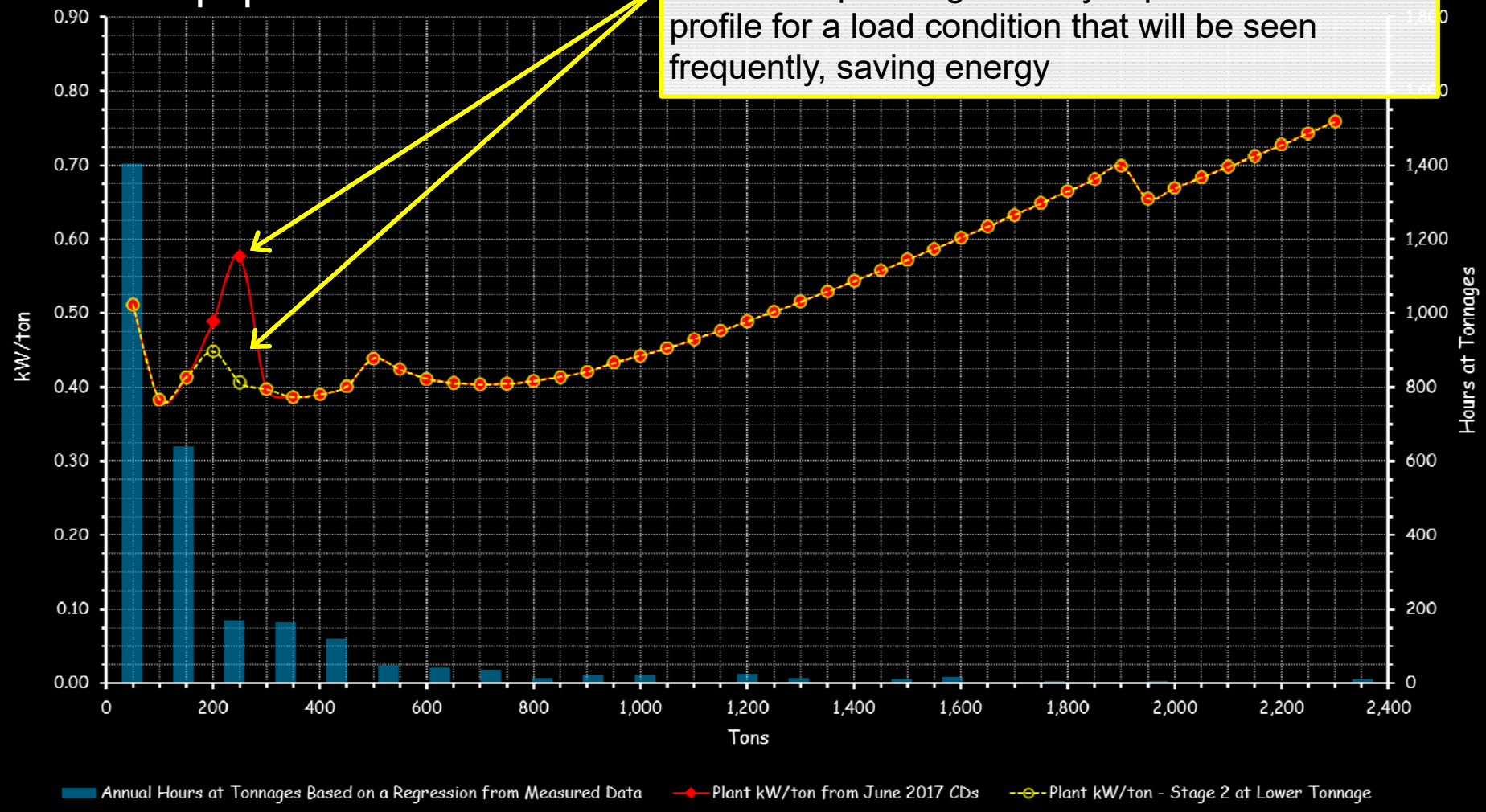
Chiller staging set points that were ideal for a plant with a different mix of chiller tonnages from the last project may be less than ideal for the new project



Set Points;

Are They Appropriate for the Equipment Selection?

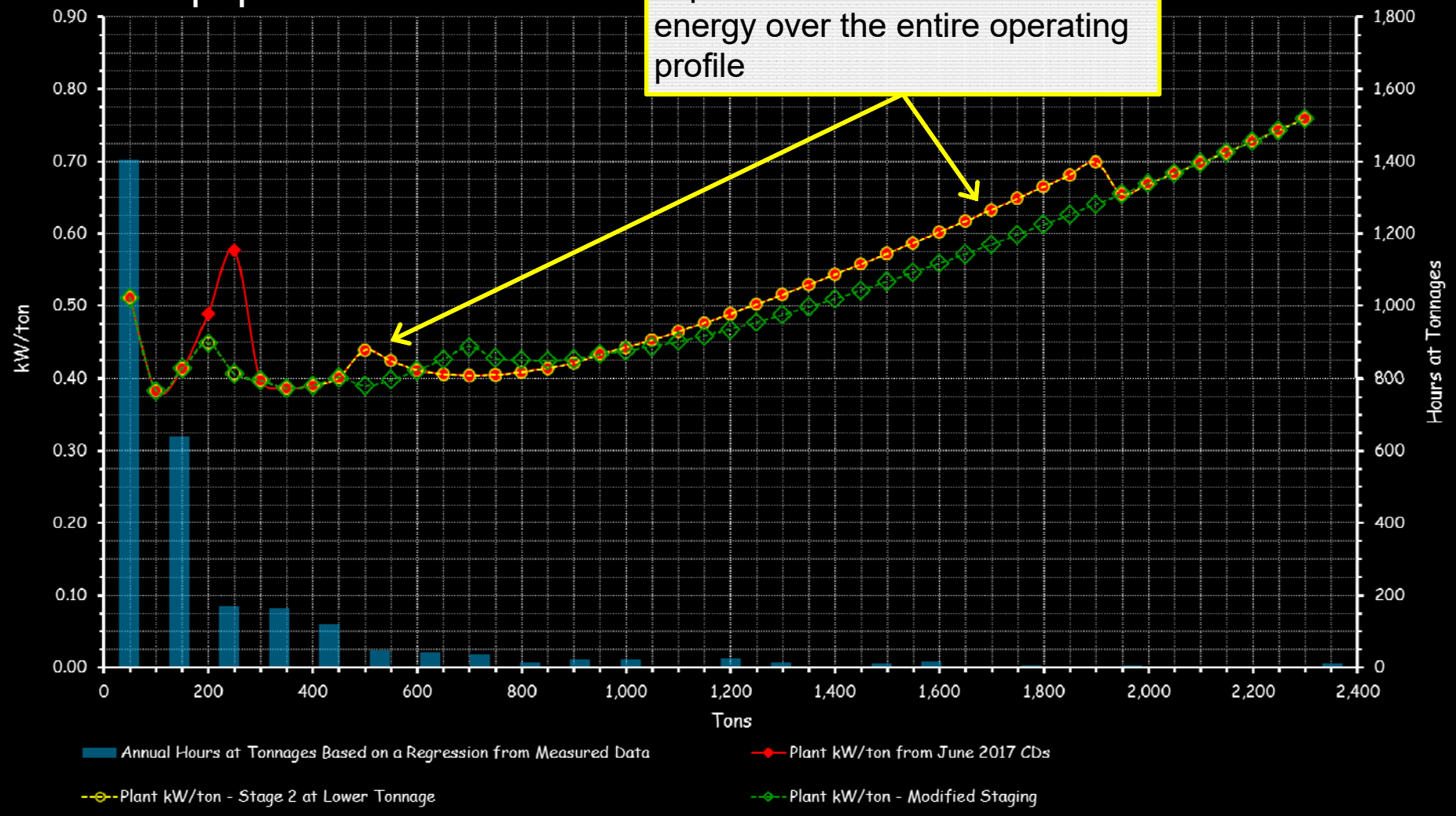
Adjusting the staging set points for moving from the 1st to 2nd stage by tailor them to the specifics of the new plant significantly improves the kW/ton profile for a load condition that will be seen frequently, saving energy



Set Points;

Are They Appropriate for the Equipment Selection?

Similar "tweaks" for the other staging set points generally make improvements that will save energy over the entire operating profile



Set Point Bottom Lines

Control logic may be a *one size fit's all* proposition for similar system types and configurations

- The decision tree for operating a large VAV system can probably be applied to any similar system

- The decision tree for staging up a variable flow, water cooled, primary only chiller plant can probably be applied to any similar system

Set Point Bottom Lines

The set points used by the *one size fit's all* decision tree will need to be tailored to the climate, load characteristics and equipment characteristics for each application

- The economizer high limit set point associated with the logic for a large VAV system in San Francisco, CA will be different for that same logic applied in St. Louis, MO

- The chiller staging set points associated with the logic that moves the plant from stage 1 to stage 2 will be different for a plant that has a mix of chiller types and sizes as compared to a plant with identical machines