HPC can't live on W3 alone!

Michael K Patterson, Intel

Future Proofing

- Data Centers need to run for 10 to 20 years
- HPC systems run for 3 to 5 years
- 4, 5, or 6 Refreshes may happen in the same building

How do I design my data center for such a lifetime?

The future is ALL about liquid cooling, right?

- Warm water has the best TCO, right?
- I keep hearing about warm water; W3
- Let's ask ASHRAE

CoolClips.com

ASHRAE

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers
- TC 9.9 – Mission Critical Spaces
  - Largest TC in ASHRAE
- High collaborative tech society organization setting guidelines for air-cooling temperatures and humidities, as well as liquid-cooling temperatures
  - Pretty much all equipment vendors actively participate

ASHRAE Air Cooling 2011 Guidelines

Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (°C) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (°C)	Maximum Elevation (m)	Maximum Rate of Change(°C/hr) (f)	Dry-Bulb Temperature (°C)	Relative Humidity (%)	Maximum Dew Point (°C)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	18 to 27	5.5ºC DP to 60% RH and 15ºC DP						
Allowable								
A1	15 to 32	20% to 80% RH	17	3050	5/20	5 to 45	8 to 80	27
A2	10 to 35	20% to 80% RH	21	3050	5/20	5 to 45	8 to 80	27
A3	5 to 40	-12˚C DP & 8% RH to 85% RH	24	3050	5/20	5 to 45	8 to 85	27
A4	5 to 45	-12˚C DP & 8% RH to 90% RH	24	3050	5/20	5 to 45	8 to 90	27
B	5 to 35	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29
C	5 to 40	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29

ASHRAE Liquid Cooling

| Liquid Cooling Classes	Typical Infrastructure Design		Facility Supply Water Temp(C)
	Main Cooling Equipment	Supplemental Cooling Equipment	
W1(see Figure 3a)	Chiller/Cooling Tower	Water-side Economizer (w drycooler or cooling tower)	2 - 17
W2(see Figure 3a)	Chiller/Cooling Tower	Water-side Economizer (w drycooler or cooling tower)	2 - 27
W3(see Figure 3a)	Cooling Tower	Chiller	2 - 32
W4(see Figure 3b)	Water-side Economizer (w drycooler or cooling tower)	N/A	2 - 45
W5(see Figure 3c) See Operational Characteristics	Building Heating System	Cooling Tower	>45

ASHRAE Liquid Cooling

Liquid Cooling Classes	Typical Infrastructure Design		Facility Supply Water Temp(C)
	Main Cooling Equipment	Supplemental Cooling Equipment	
W1(see Figure 3a)	Chiller/Cooling Tower	Water-side Economizer (w drycooler or cooling tower)	2 - 17
W2(see Figure 3a)			2 - 27
W3(see Figure 3a)	Cooling Tower	Chiller	2 - 32
W4(see Figure 3b)	Water-side Economizer (w drycooler or cooling tower)	N/A	2 - 45
W5(see Figure 3c) See Operational Characteristics	Building Heating System	Cooling Tower	>45

Maximizing Efficiency while Minimizing TCO

- It makes no difference;
  Air-Cooling or Liquid-Cooling….
- The best starting point for your new data center design is to run it AS COLD AS POSSIBLE without a chiller
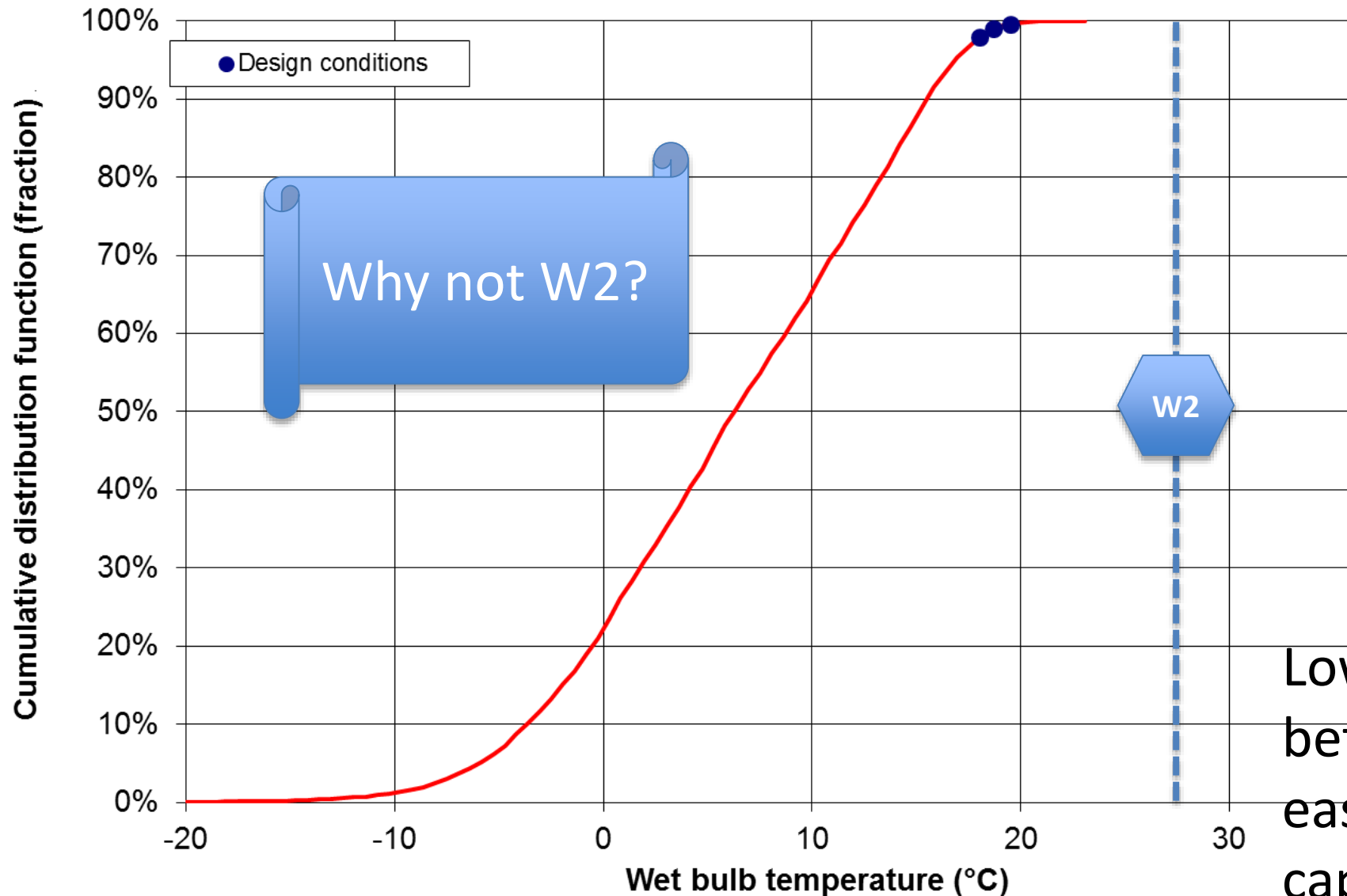
Show me….

	Power
Server Power	2420 kW
CRAC Fan	111 kW
CW Pump	25 kW
Tower Pump	20 kW
Compressor	626 kW
Tower Fan	44 kW
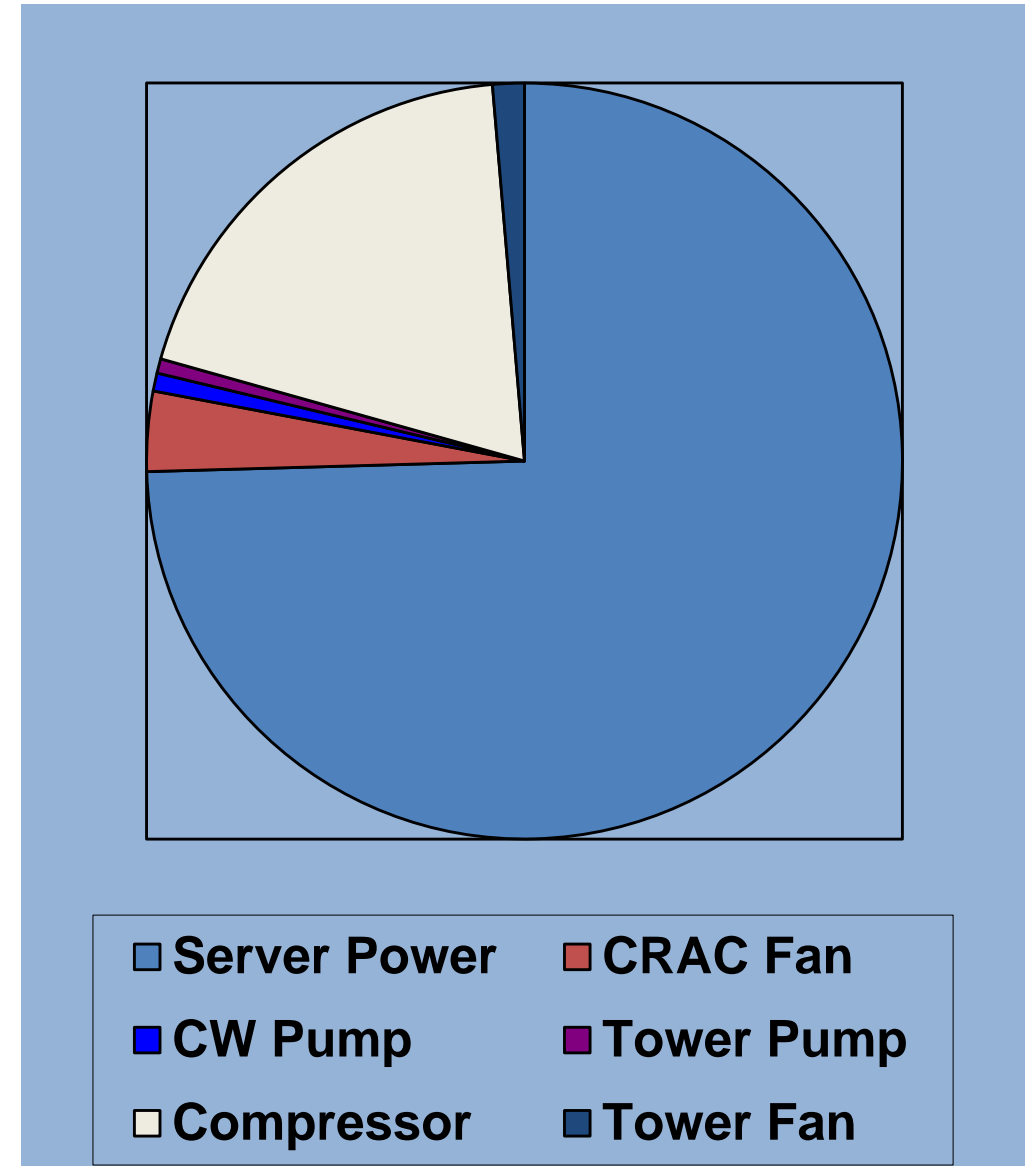
Wet bulb temperature cumulative distribution function - Annual
SALT LAKE CITY INT'L ARPT, UT, USA (725720)

Psychrometrics – a "map" of air
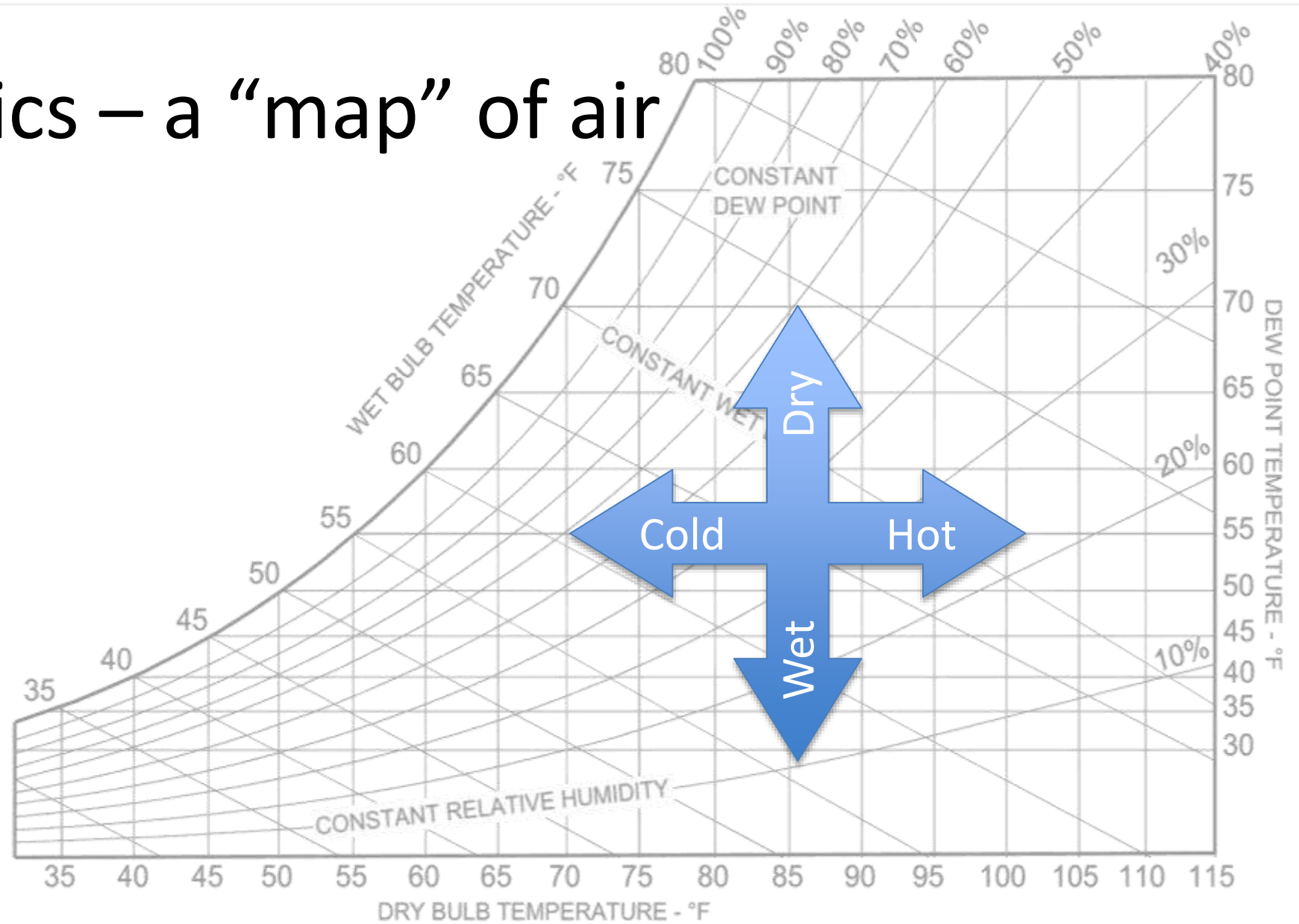
2011 ASHRAE Air-Cooled Thermal Guidelines
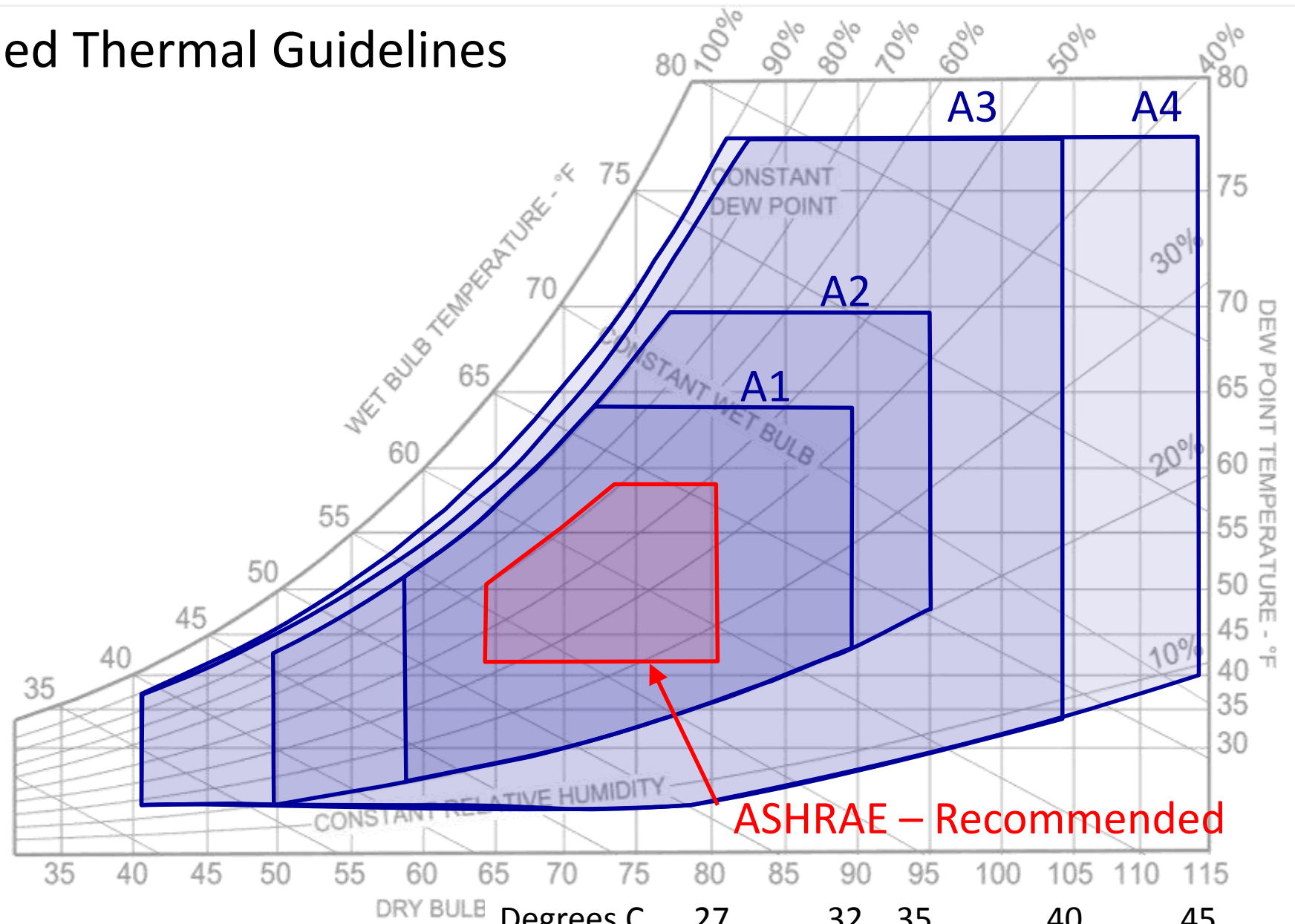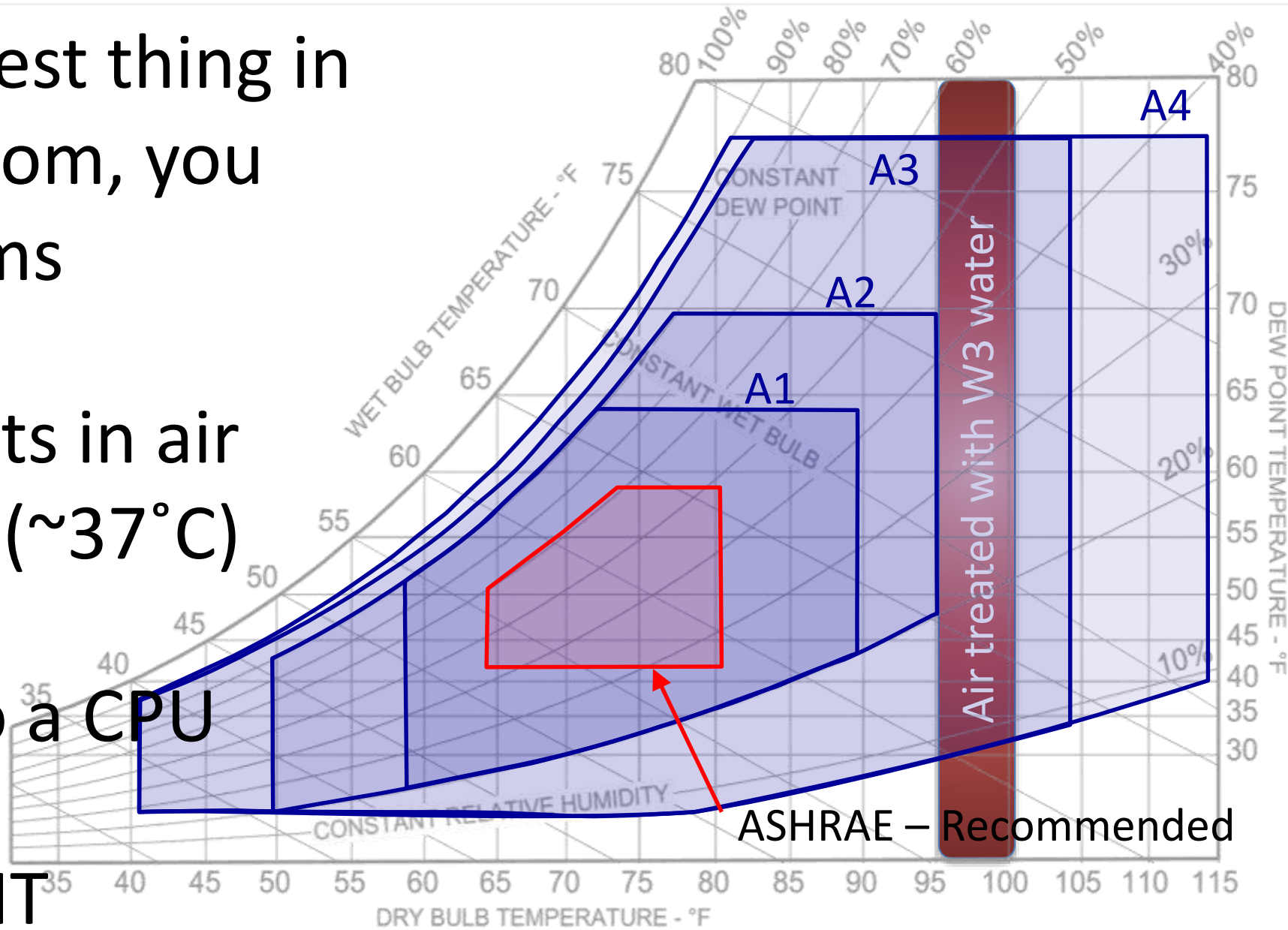

*Envelopes Represent Conditions at IT Equipment Inlet

ASHRAE – Recommended

Degrees C	27		32	35		40	45
Class	R		A1	A2		A3	A4

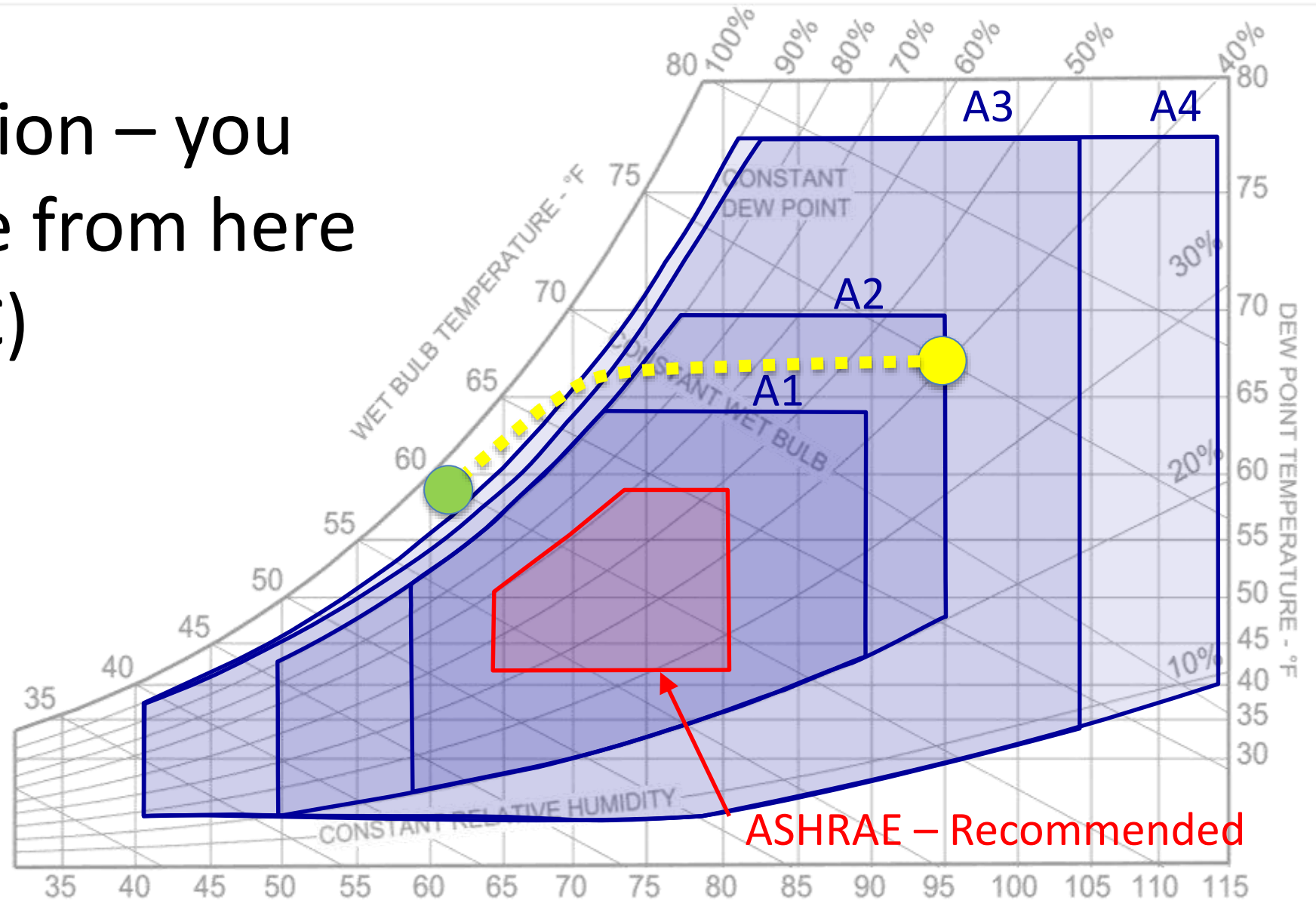If W3 is the coldest thing in your machine room, you have big problems

32˚C water results in air that's too warm (~37˚C)

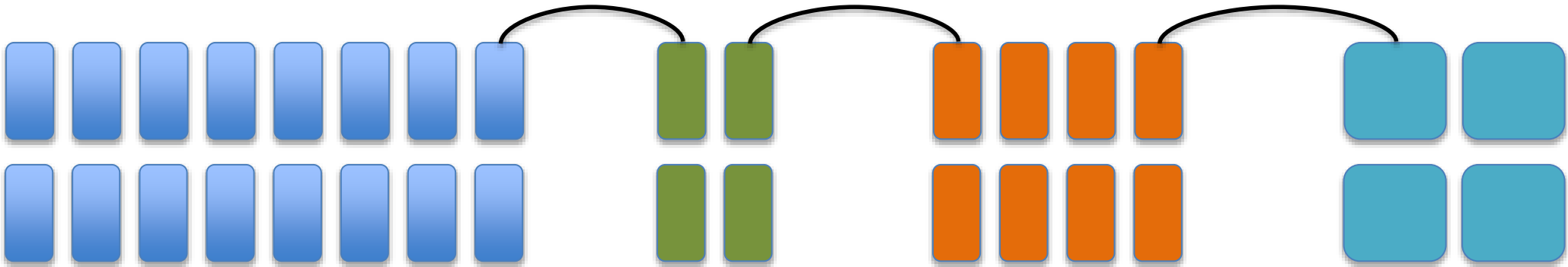32˚C is "cold" to a CPU

37˚C is "hot" to IT

Dehumidification – you can't get there from here with W3 (32˚C)

A3
A4
A2
A1

ASHRAE – Recommended

Degrees C	27		32	35		40	45
Class	R		A1	A2		A3	A4

Your System at A2 – allowable
~35°C (95°F)

| Compute | Service | Storage | Archive | Tech |
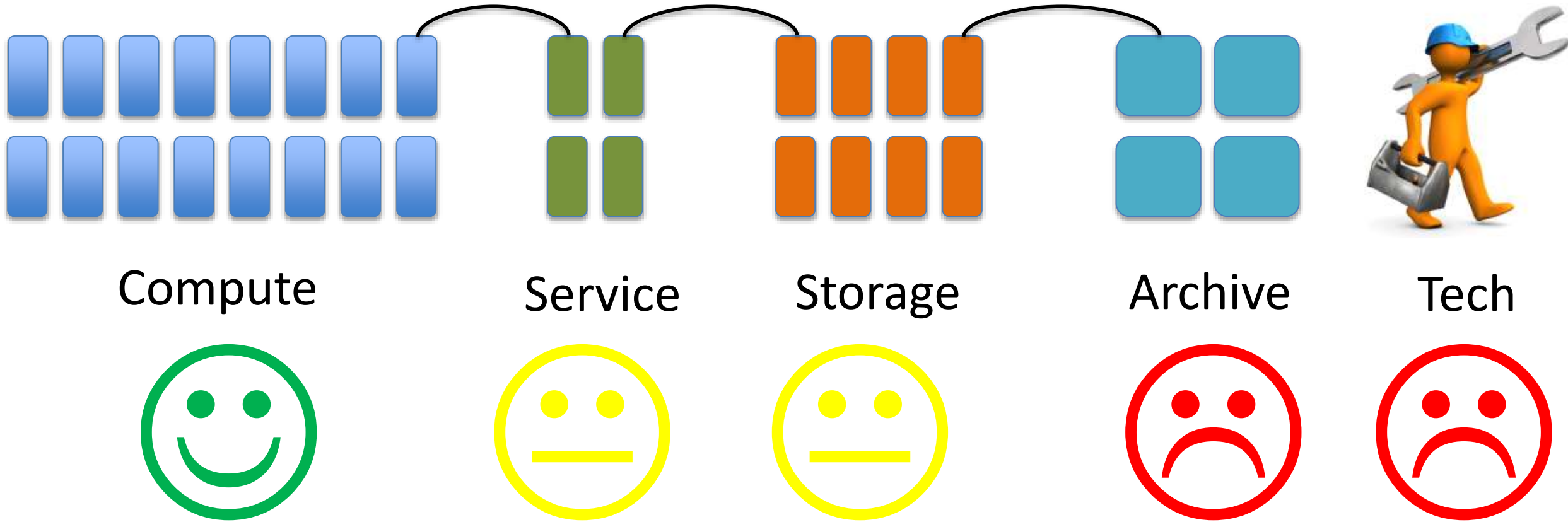
Your System at W3 only
….air temperatures and humidity too high!

Compute   Service   Storage   Archive   Tech
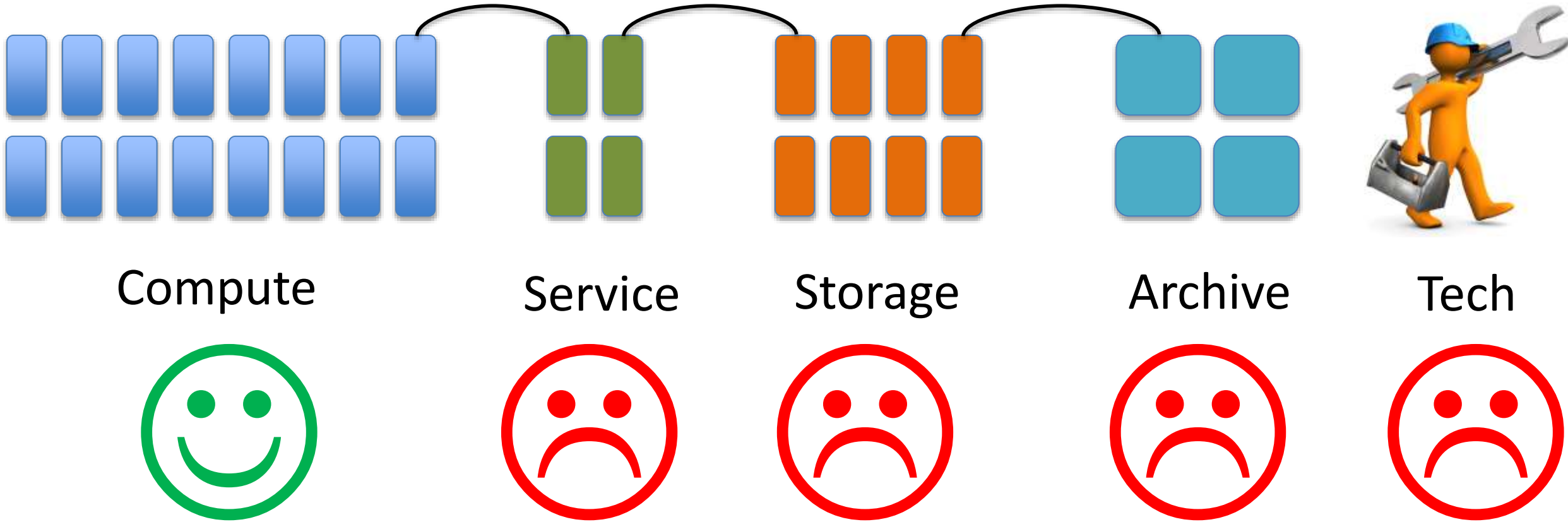
Summary

- Liquid cooling can be a huge boost for performance and heat removal
- But don't forget the air-cooled gear; temperature and humidity
- HPC can't live on W3 alone!

**Remember! Start here: as cold as you can, with out a chiller
(and don't forget the other stuff)**

Thank you!

Please save your questions for the end of the session.
eehpcwg.llnl.gov