

HPC can't live  
on W3 alone!

**E2**  
**HPC**  
**Working Group**

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# 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



# 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)
<b>Recommended</b> (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	5.5°C DP to 60% RH and 15°C DP						
<b>Allowable</b>								
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

	Typical Infrastructure Design		
Liquid Cooling Classes	Main Cooling Equipment	Supplemental Cooling Equipment	Facility Supply Water Temp(C)
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

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W1(see Figure 3a)	Chiller/Cooling Tower	Water-side Economizer	2 - 17
W2(see Figure 3a)		(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

# Maximizing Efficiency while Minimizing TCO

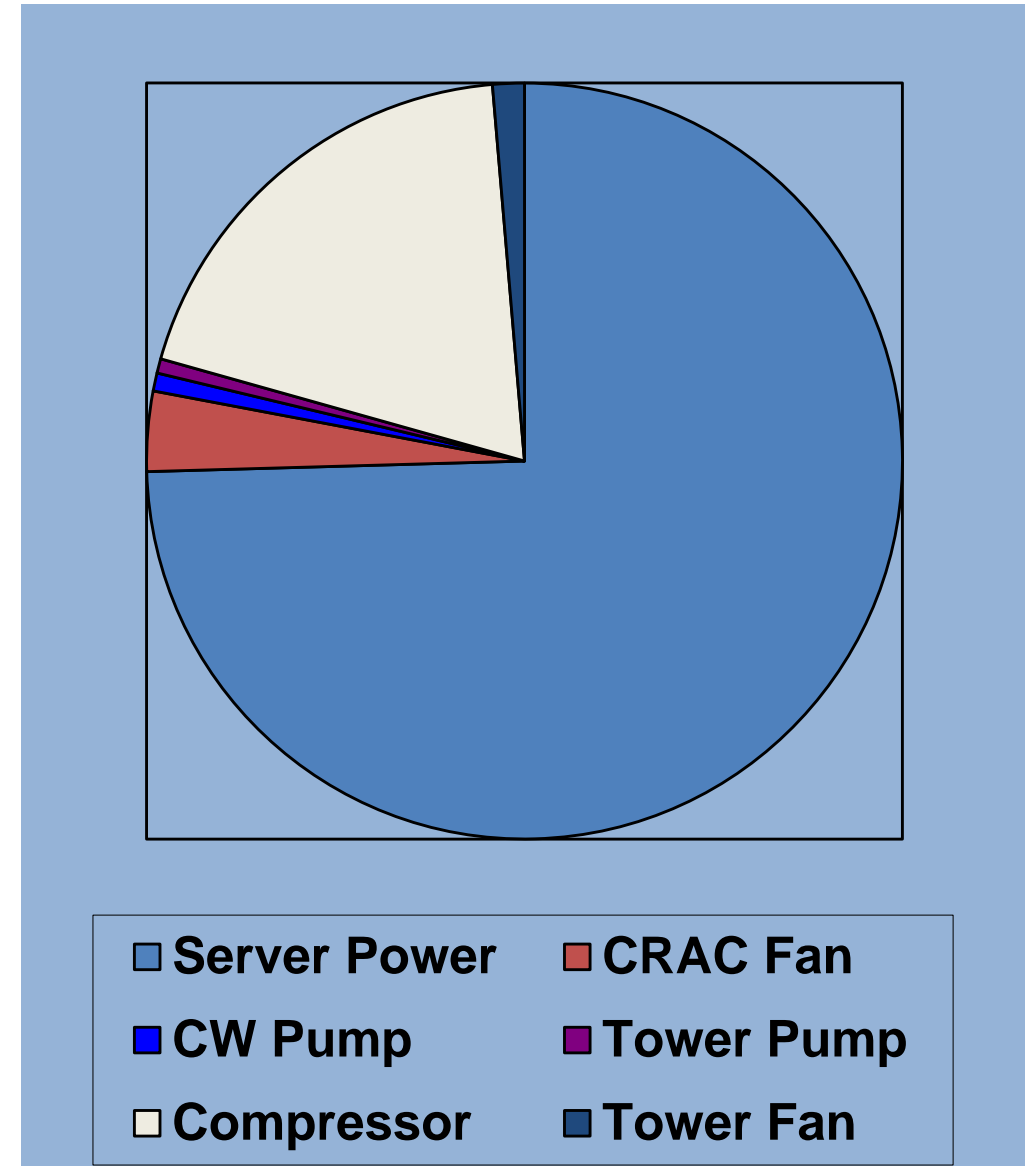
- It makes no difference;  
Air-Cooling or Liquid-Cooling....
- The best starting point for your new data center design is to run it AS COLD AS POSSIBLE without a chiller



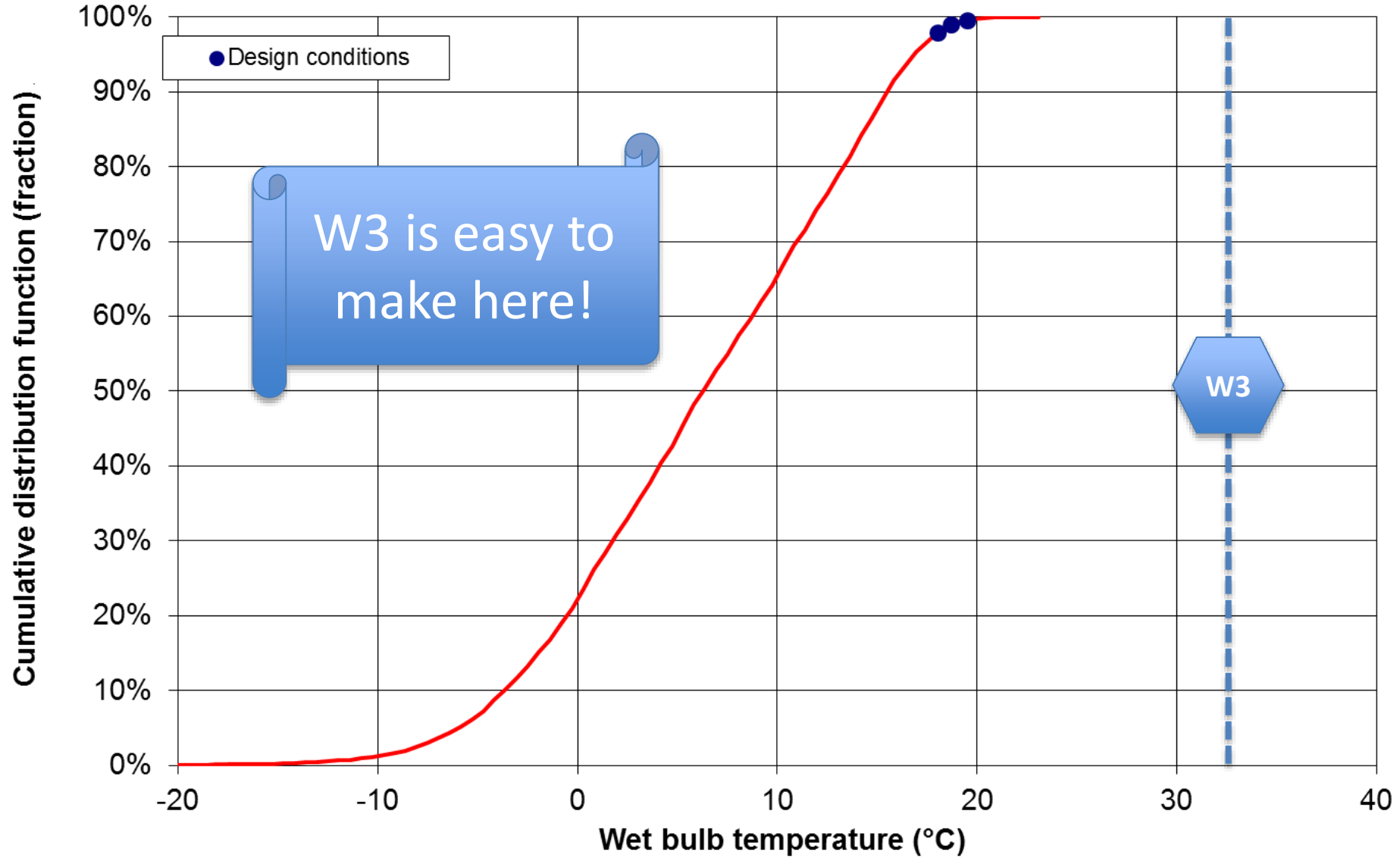


# Show me....

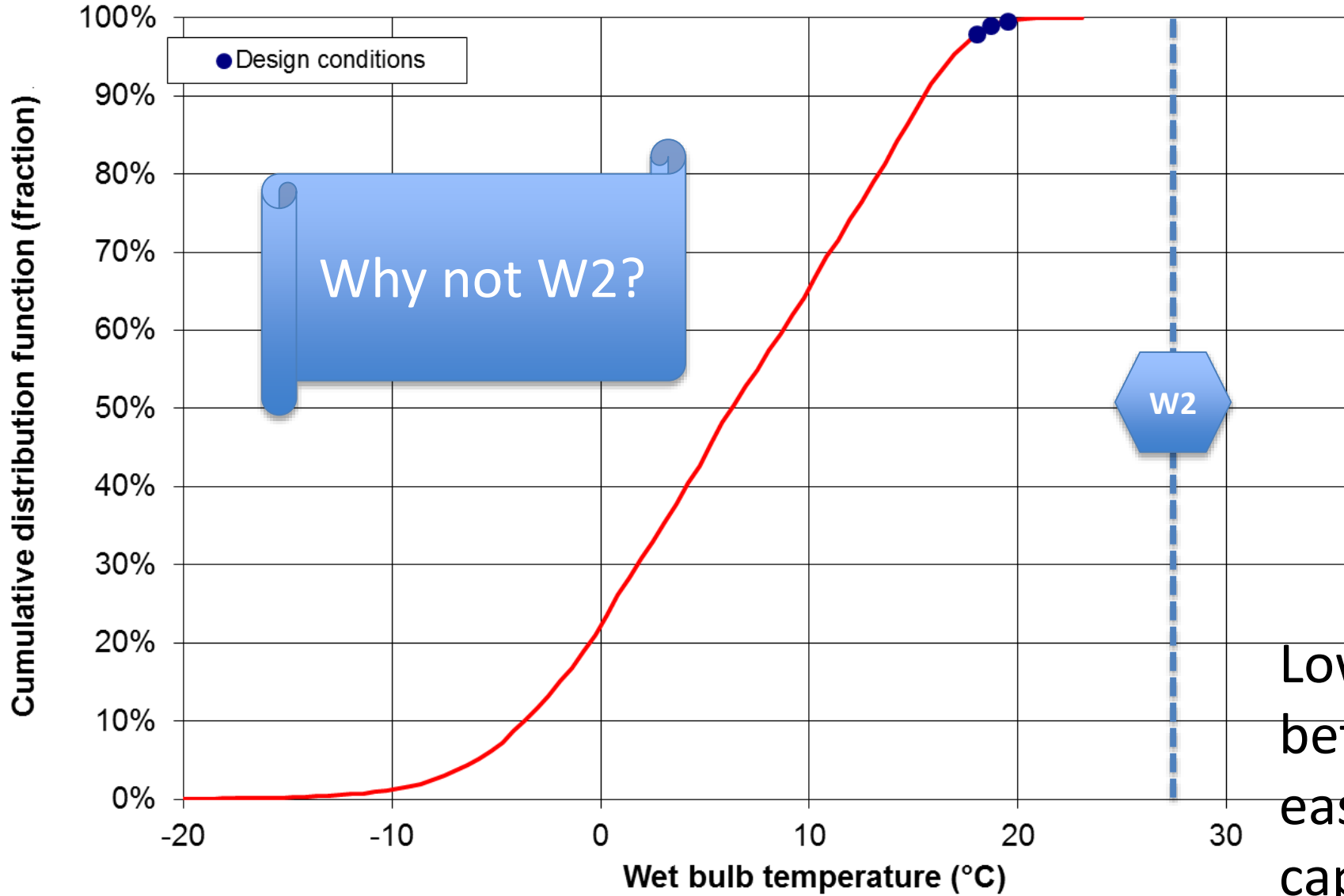
	Power
Server Power	2420 kW
CRAC Fan	111 kW
CW Pump	25 kW
Tower Pump	20 kW
Compressor	626 kW
Tower Fan	44 kW



# Wet bulb temperature cumulative distribution function - Annual SALT LAKE CITY INT'L ARPT, UT, USA (725720)



Wet bulb temperature cumulative distribution function - Annual  
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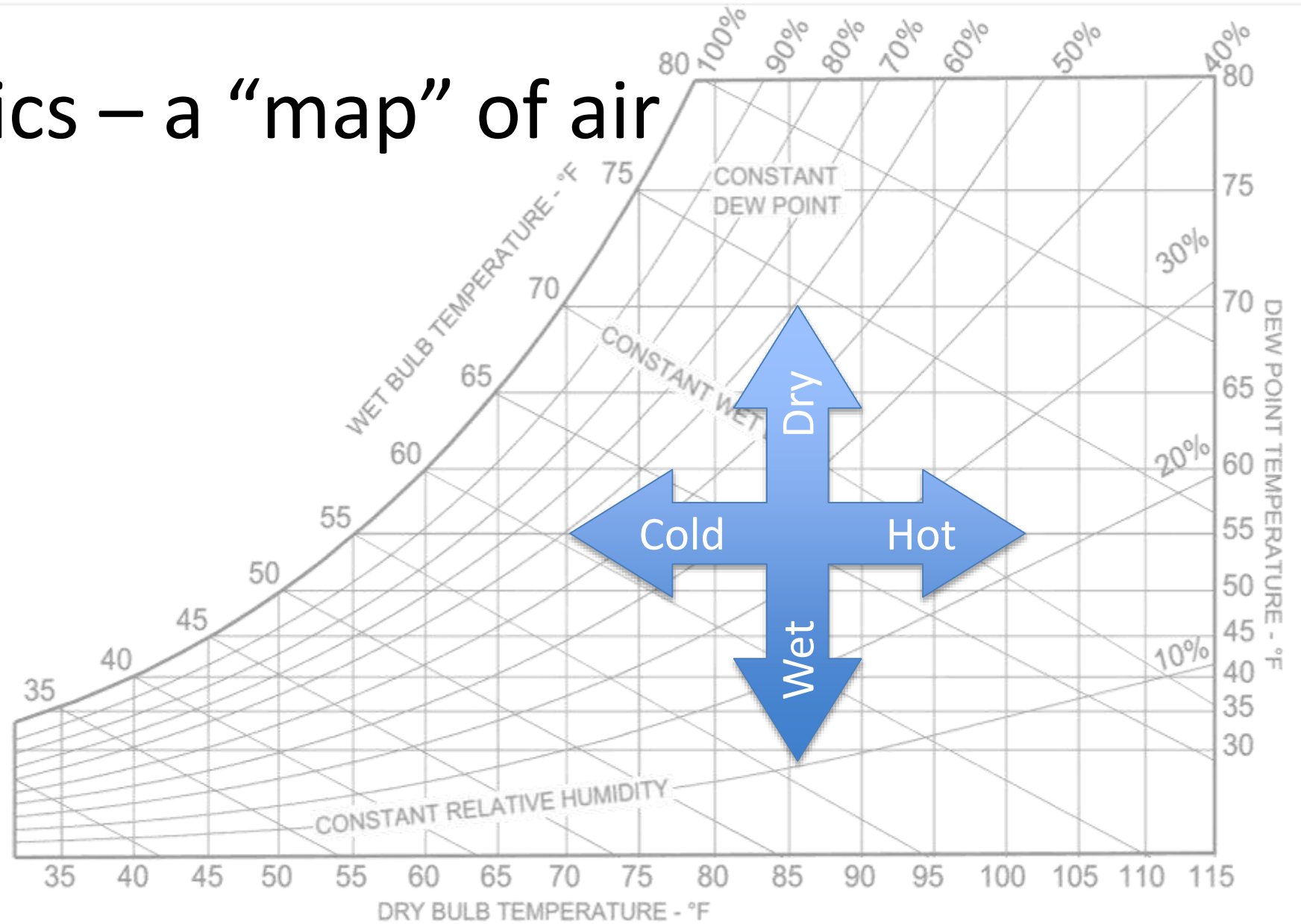
Why not W2?

W2

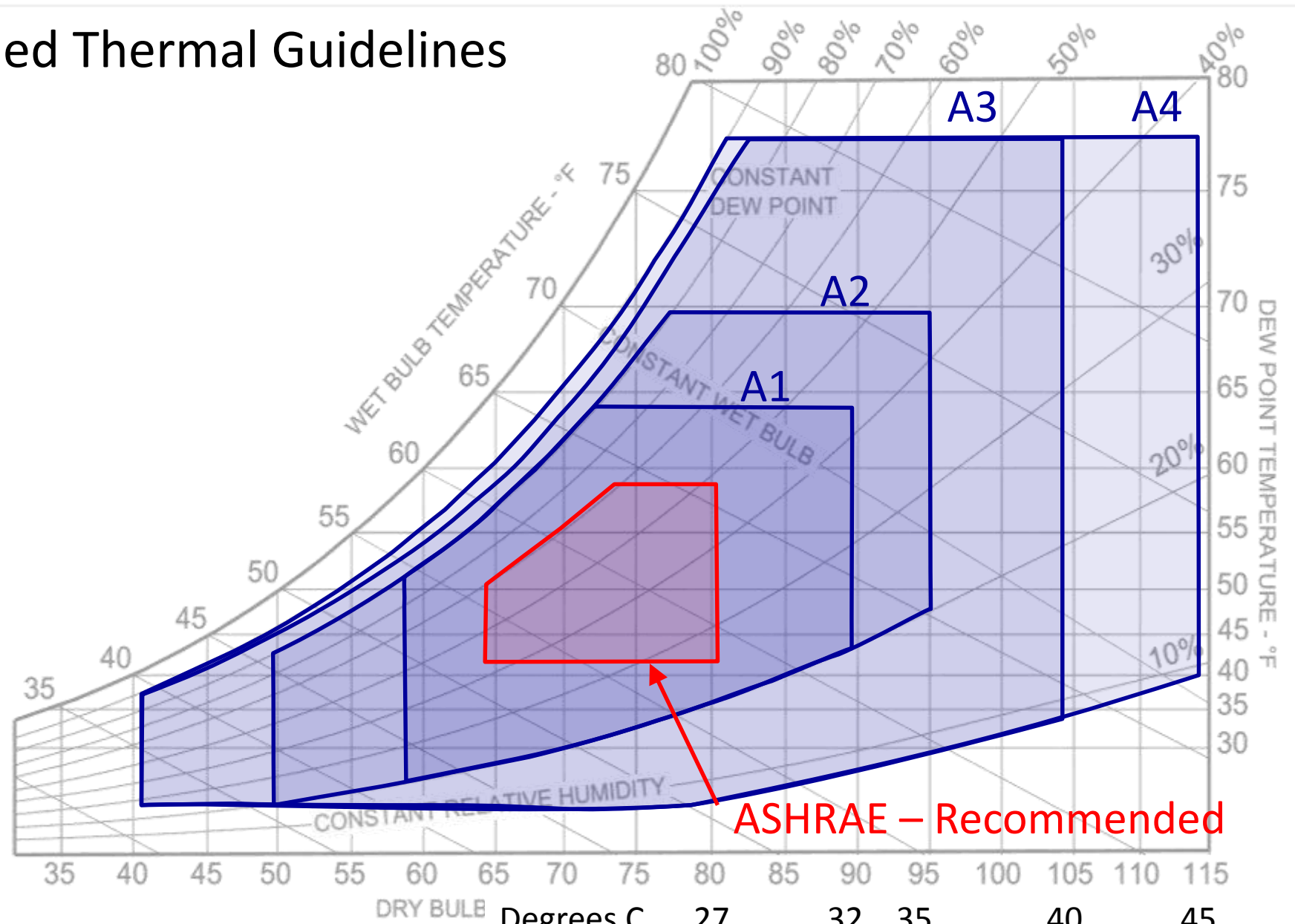


Lower temperatures drive better performance, its an easy trade for extra cooling capacities...

# Psychrometrics – a “map” of air



# 2011 ASHRAE Air-Cooled Thermal Guidelines



\*Envelopes Represent Conditions at IT Equipment Inlet

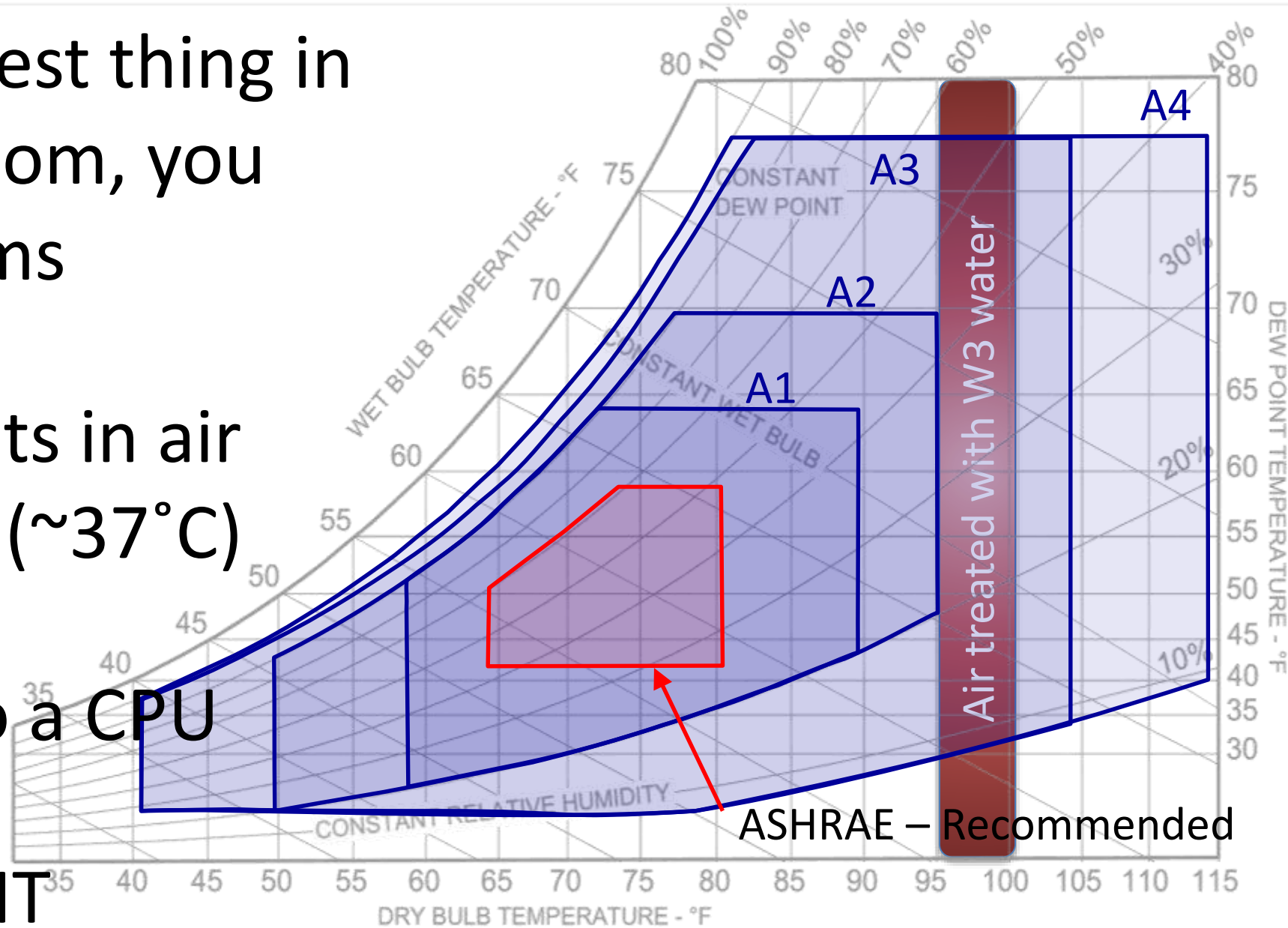
Class	R	A1	A2	A3	A4
Dry Bulb (°C)	27	32	35	40	45

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)

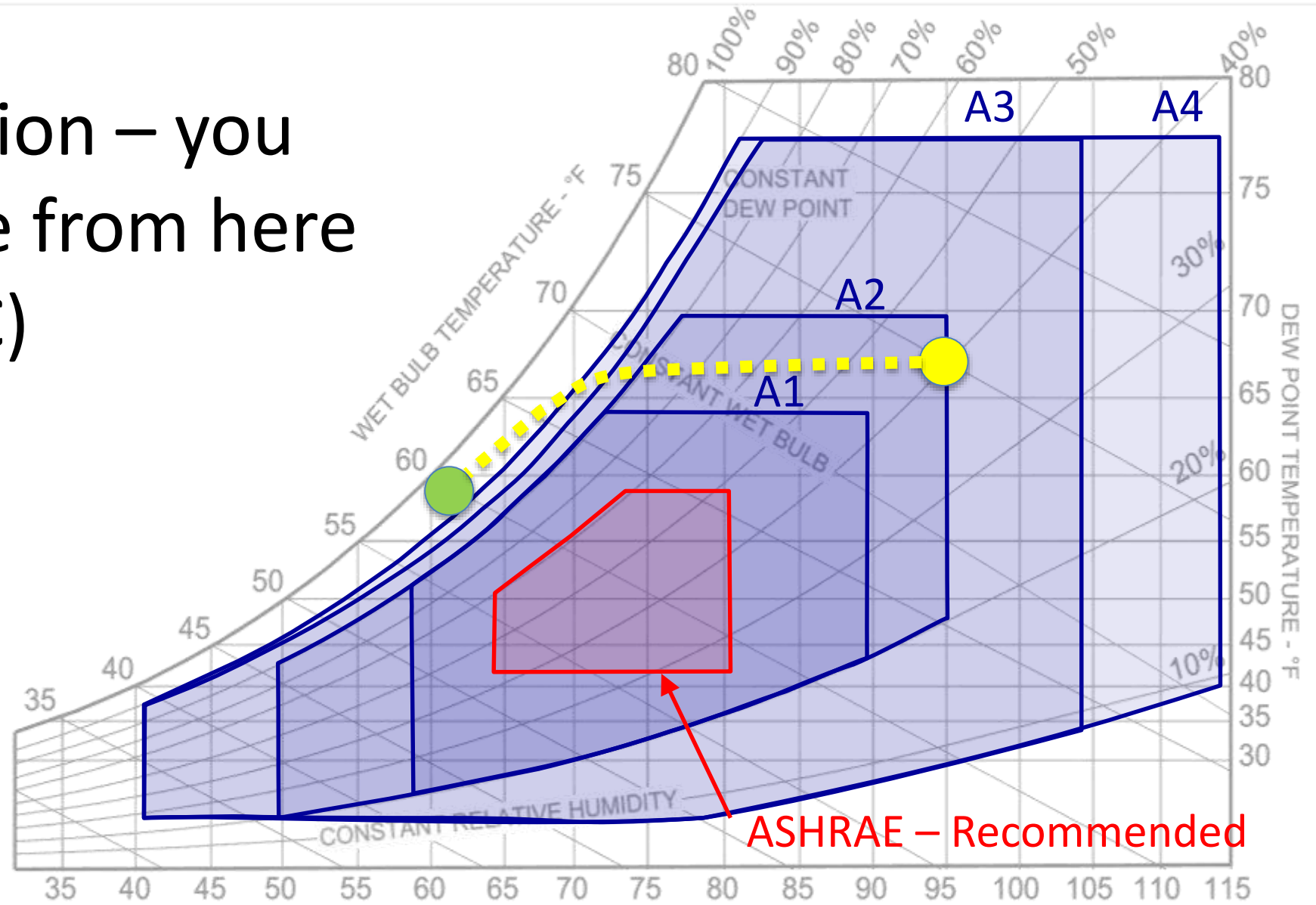
32°C is "cold" to a CPU

37°C is "hot" to IT





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

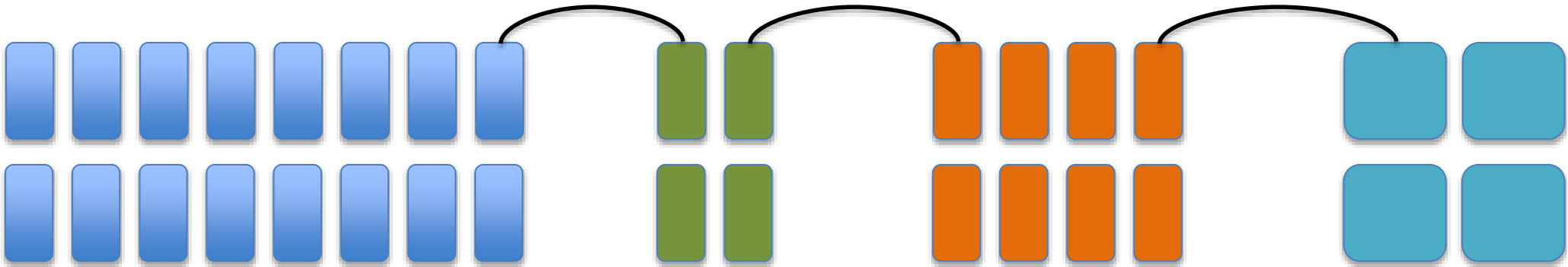


ASHRAE – Recommended

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

# Your System at A1 – recommended

~27°C (81°F)



Compute



Service



Storage



Archive

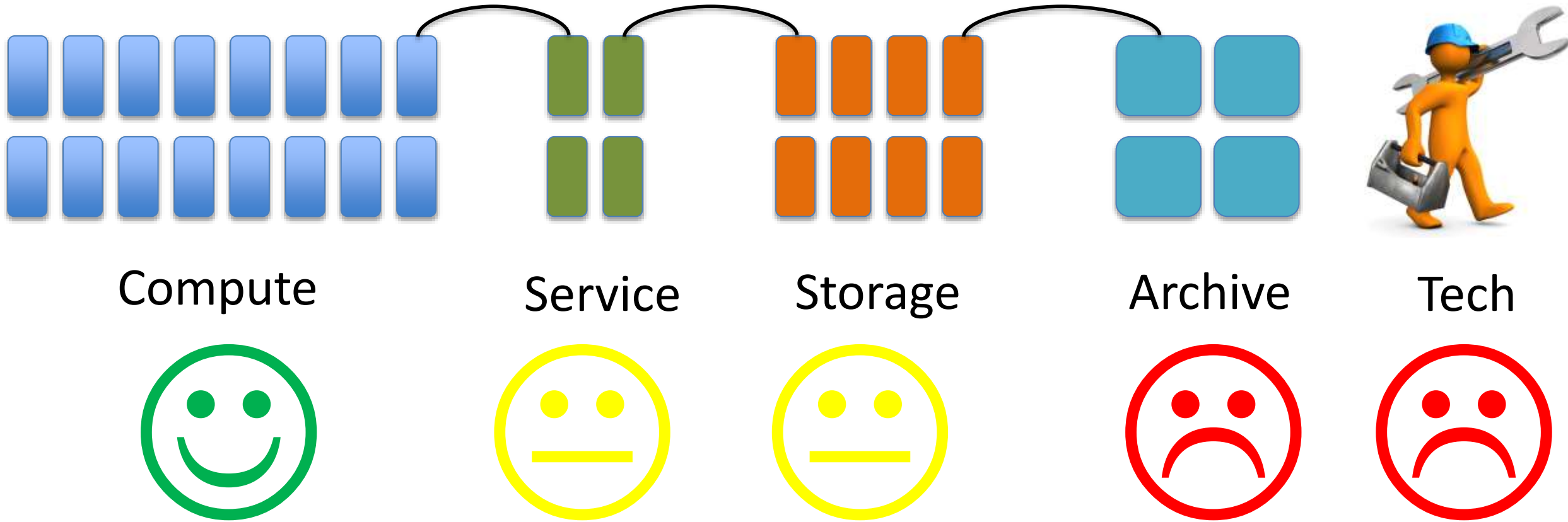


Tech



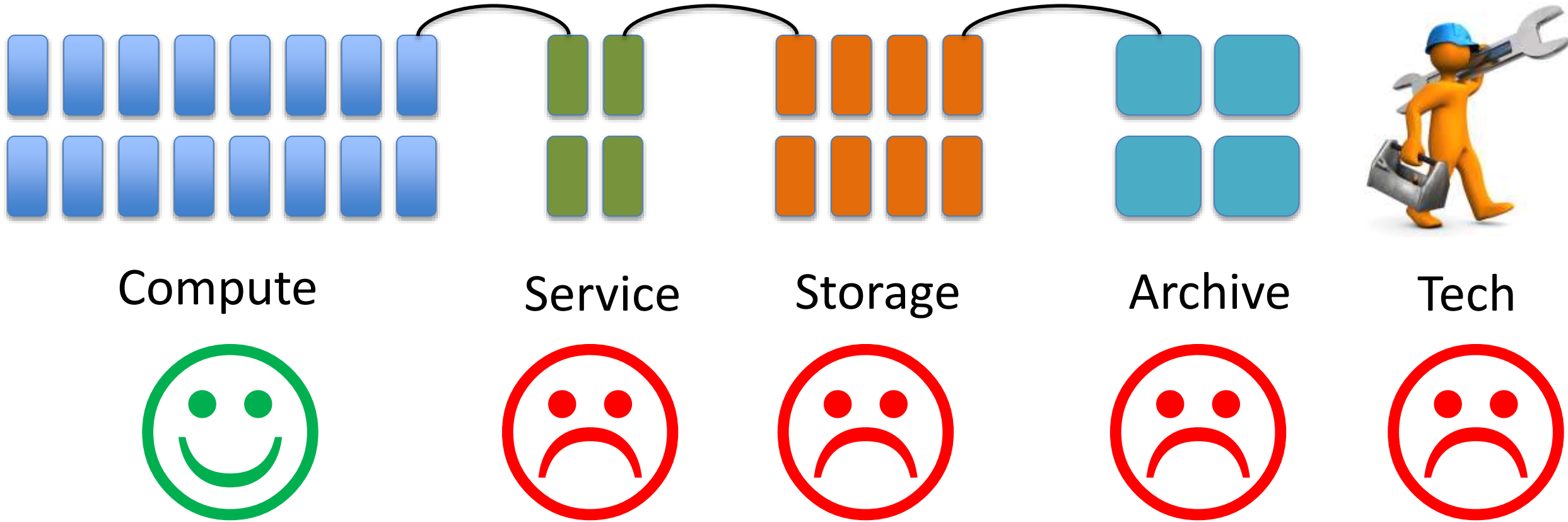


# Your System at A2 – allowable ~35°C (95°F)



# Your System at W3 only

...air temperatures and humidity too high!



# 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)**



**E<sup>2</sup>**  
**HPC**  
**Working Group**

**Thank you!**

Please save your questions  
for the end of the session.  
[eehpcwg.llnl.gov](http://eehpcwg.llnl.gov)