KUUL
EVAPORATIVE TECHNOLOGIES

Efficiency gains achieved by moving to ASHRAE allowable temperature ranges at data centers with direct evaporative cooling

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Summary

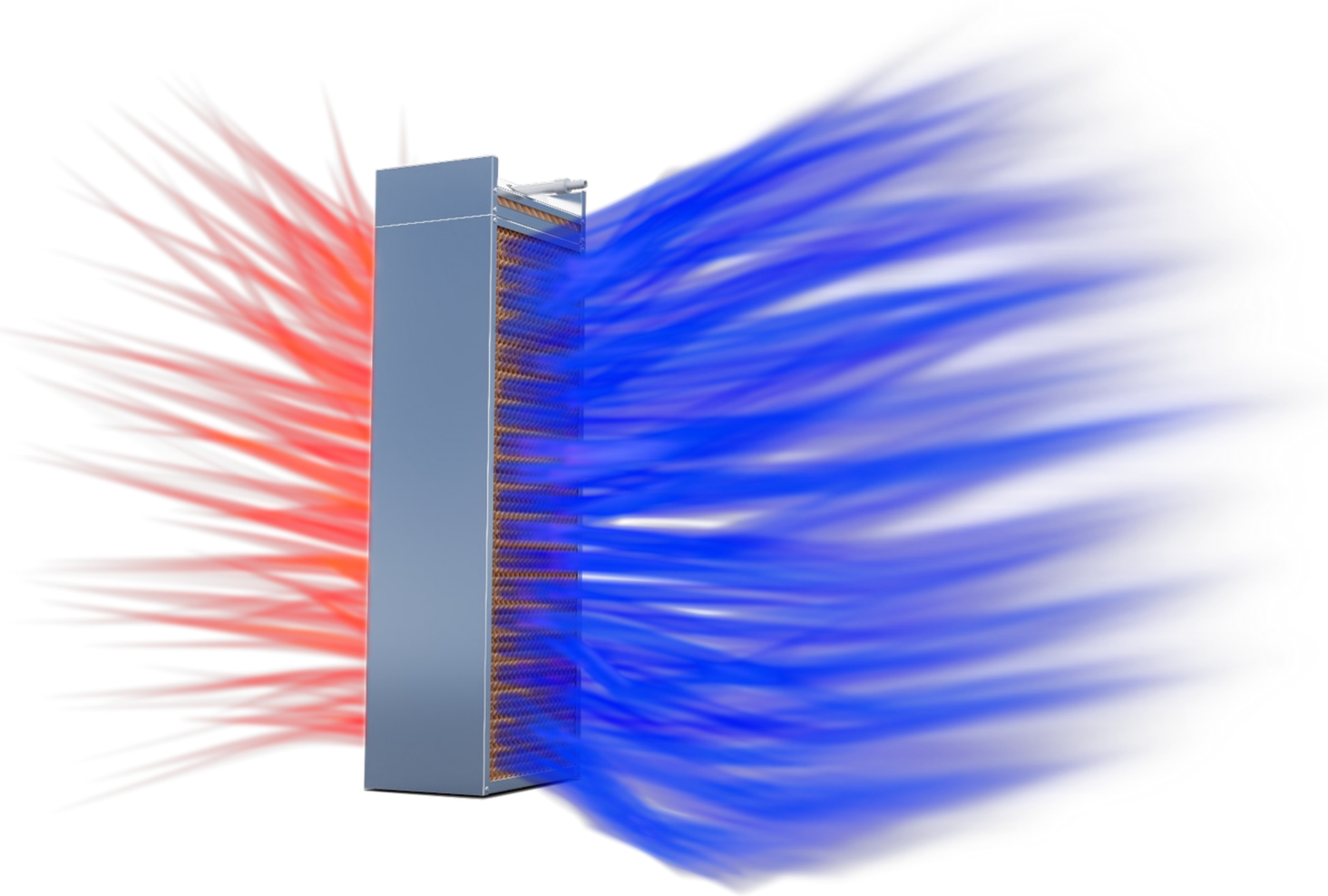
As data center designers and operators look for ways to optimize system operations and meet sustainability objectives, one of the most impactful changes is the move from ASHRAE's recommended temperature range to allowable ranges. Increasing the server inlet temperature decreases the hours per year that direct evaporative cooling systems will be evaporating water. Making these changes can decrease power and water consumption and increase the life of evaporative media.

Agenda

- Direct Evaporative Cooling Background
- Direct Evaporative Cooling Components
- TC9.9 Thermal Guidelines
- Benefits of Utilizing Expanded Envelopes
- Considerations

What is DEC?

Direct Evaporative Cooling (DEC), also known as direct adiabatic cooling or wet bulb cooling, is called direct as there is direct contact between the water and the cooling air stream.

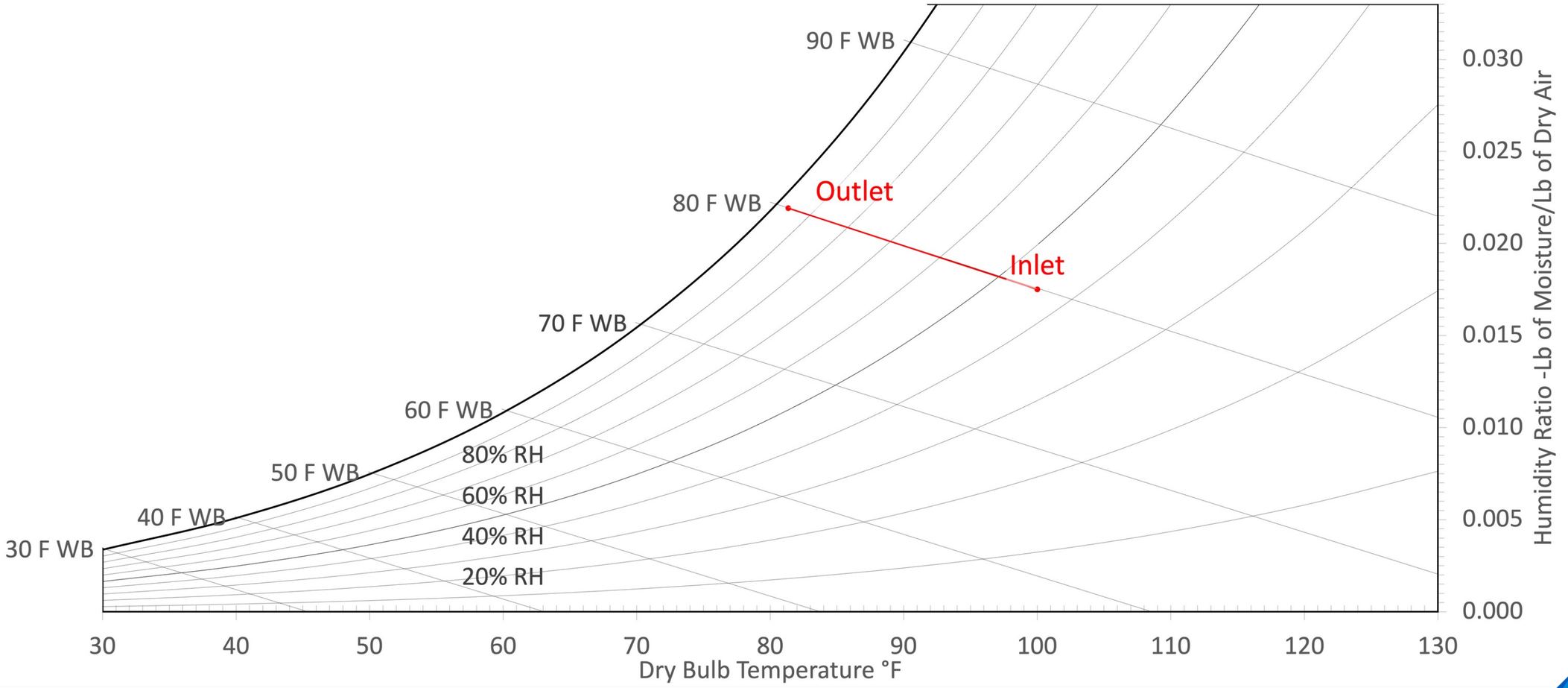


Direct Saturation Efficiency

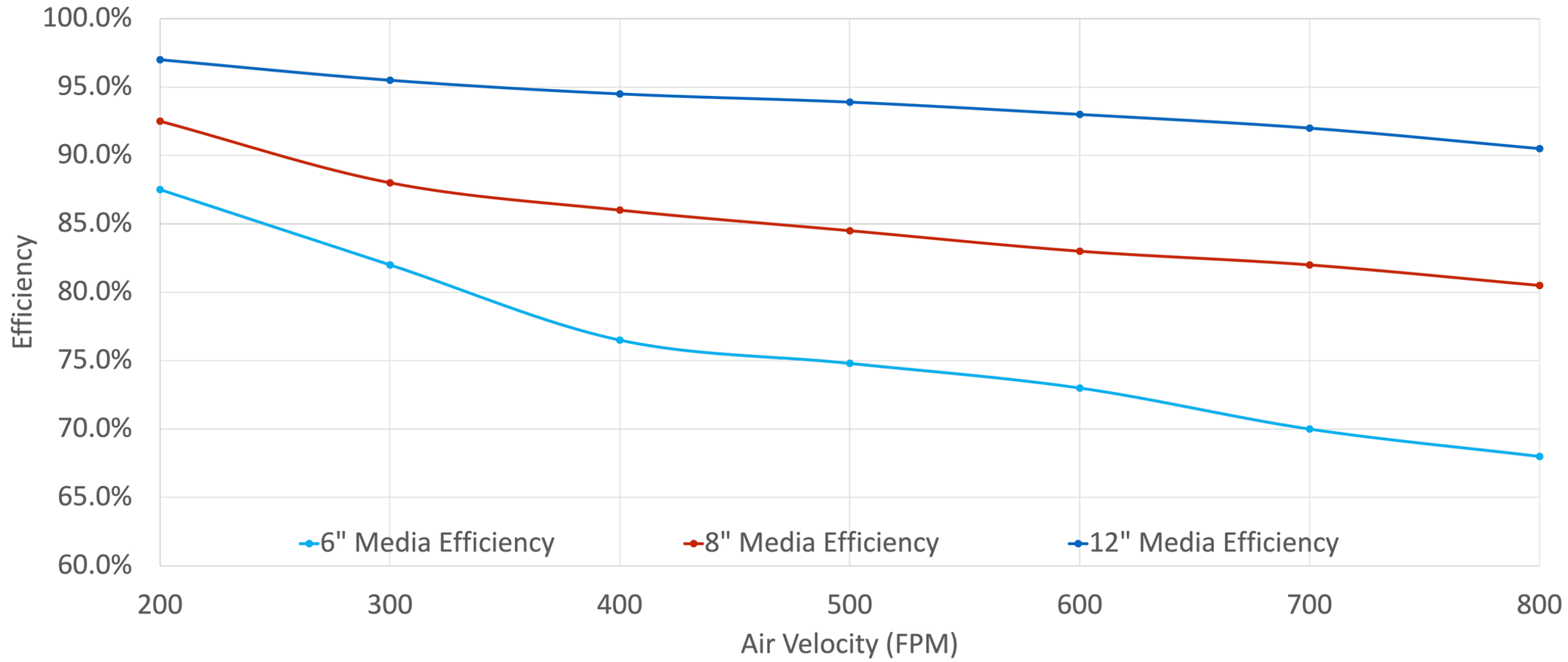
$$\varepsilon_e = 100 * \frac{(t1 - t2)}{(t1 - ts')}$$

ε_e = Direct evaporative cooling saturation efficiency, %
$t1$ = dry-bulb temperature of entering air, °F
$t2$ = dry-bulb temperature of leaving air, °F
ts' = thermodynamic wet-bulb temperature of entering air, °F

Psychrometric



Efficiency


100.0%
95.0%
90.0%
85.0%
80.0%
75.0%
70.0%
65.0%
60.0%
Efficiency
6" Media Efficiency
8" Media Efficiency
12" Media Efficiency
200
300
400
500
600
700
800
Air Velocity (FPM)

Achievable Temperature

$$LAT = (Db - Wb) * \varepsilon_e$$

LAT = Leaving air temperature

(Db - Wb) = Wet bulb depression

ε_e = Direct saturation efficiency

Evaporation Rate

$$Evaporation = V * \rho_{air} * (W_{out} - W_{in})$$

$\text{Evaporation} \left(\frac{\text{lb}}{\text{hr}}\right)$

$V = \text{Airflow} \left(\frac{\text{ft}^3}{\text{min}}\right)$

$\rho_{air} = Density\ of\ air \left(\frac{lb}{ft^3}\right)$

$W_{out} = Absolute\ humidity\ of\ outlet\ air \left(\frac{lb\ moisture}{lb\ dry\ air}\right)$

$W_{in} = Absolute\ humidity\ of\ inlet\ air \left(\frac{lb\ moisture}{lb\ dry\ air}\right)$

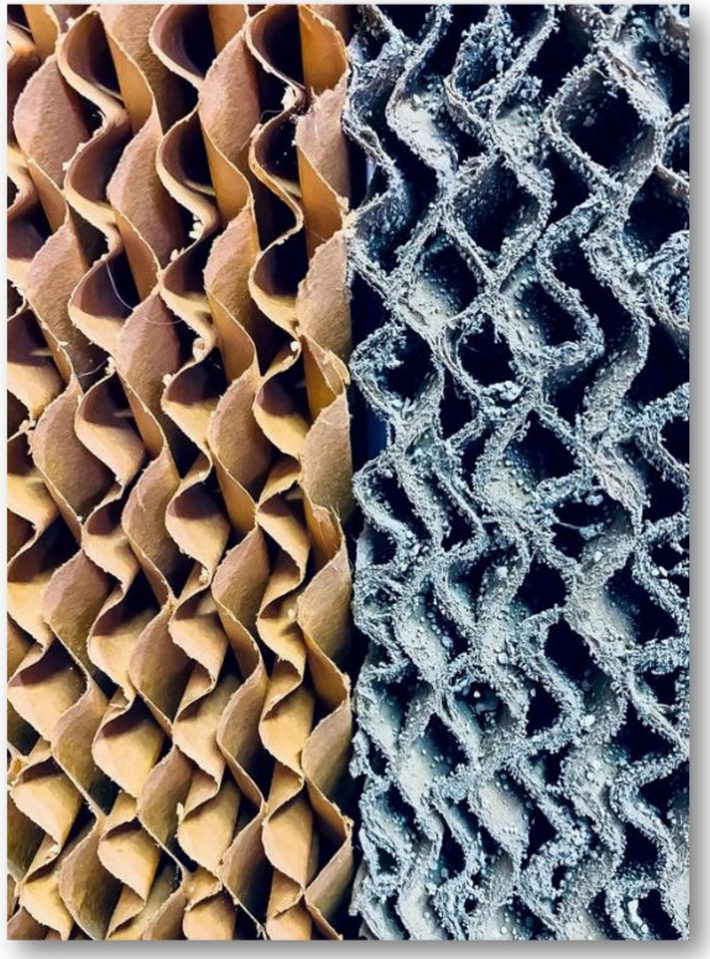
Total Water Consumption

$$Makeup = Evaporation + Blowdown$$

$$Blowdown = \frac{Evaporation}{(CoC - 1)}$$

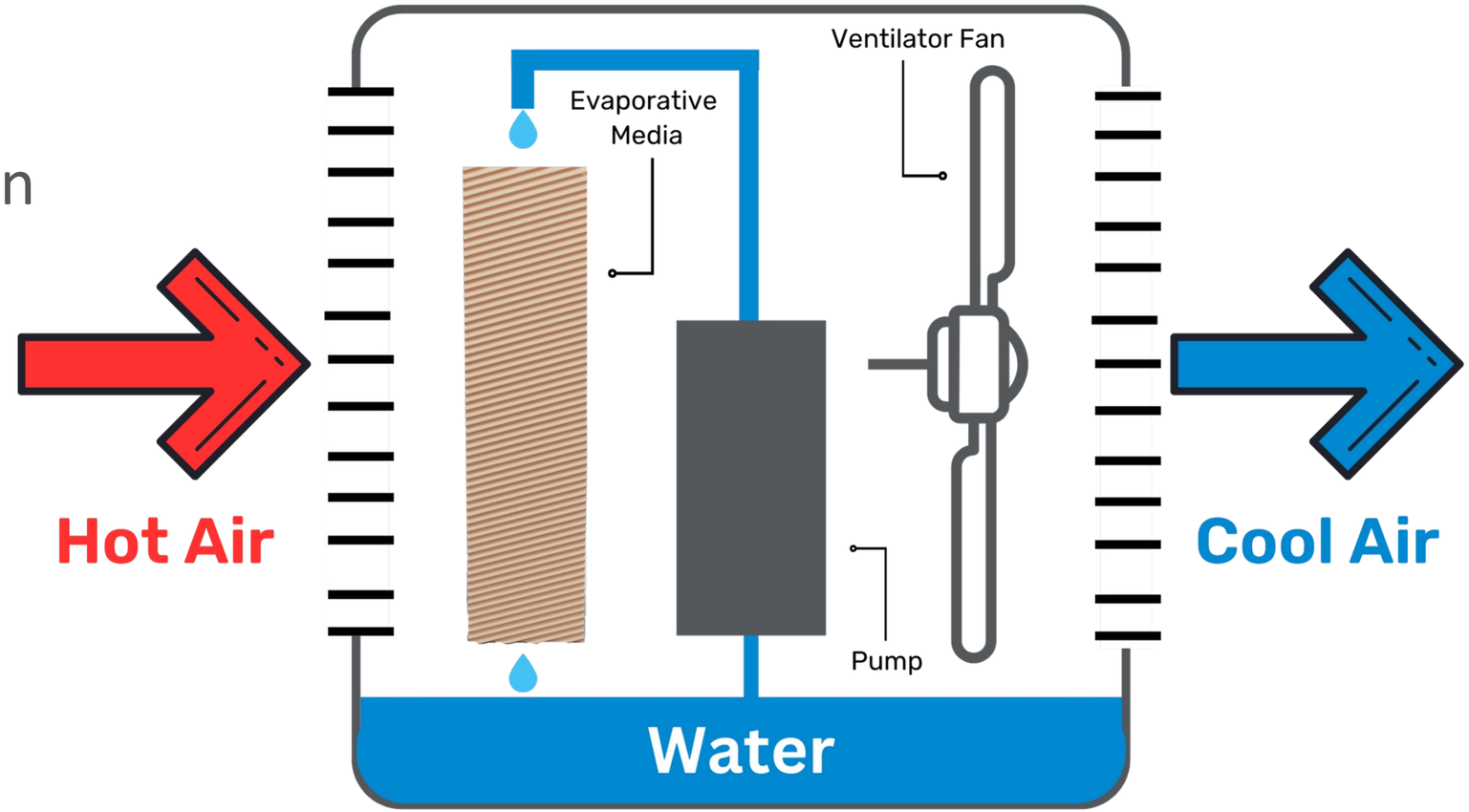
CoC Determined by:

- pH
- Mineral content
- Scaling tolerance
- Bacteria (drying requirements/hygiene purges)



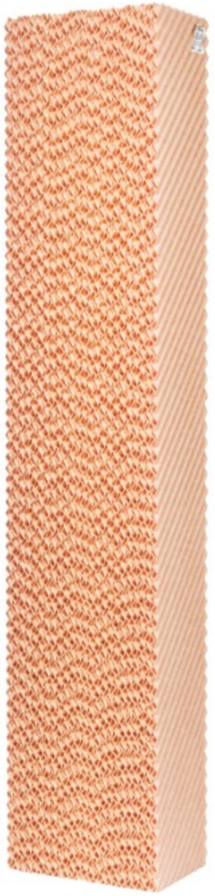
Components of a DEC System

- Evaporative media
- Water supply & distribution
- Air delivery system



Rigid Media

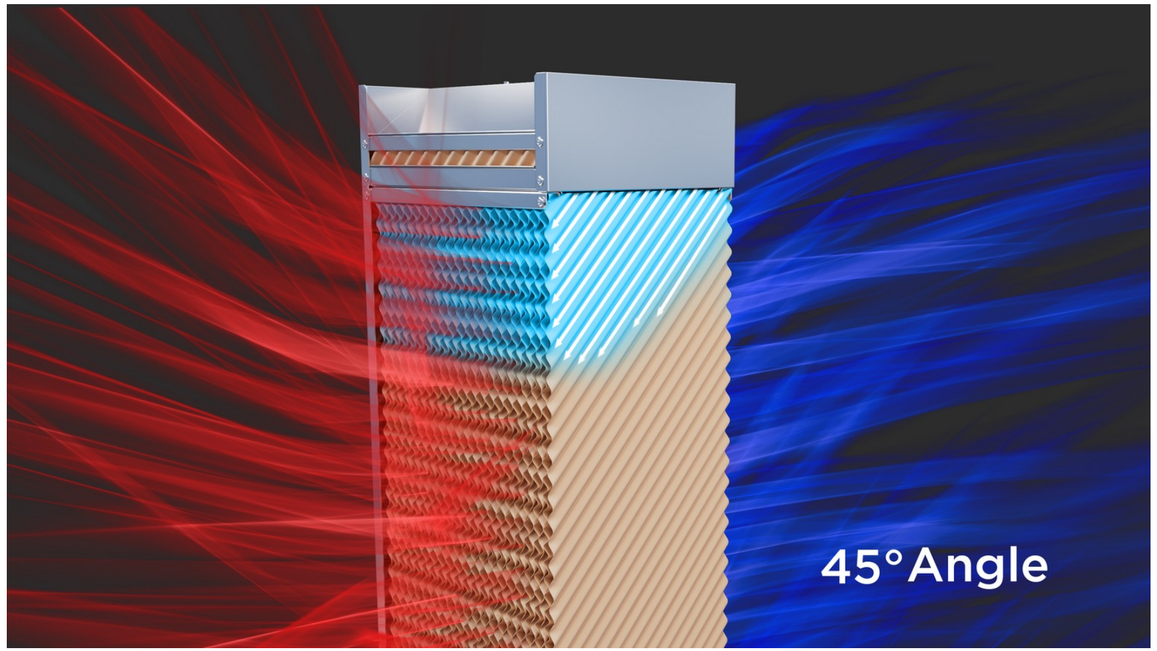
Cellulose



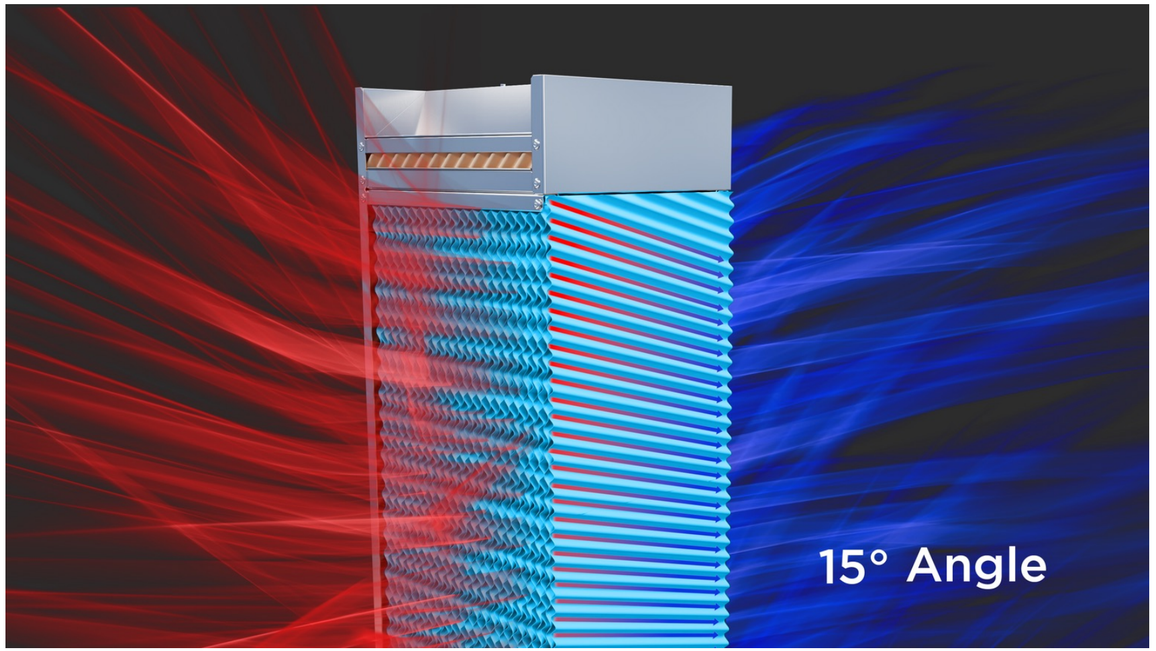
Fiberglass

PVC

Rigid Media Air/Water Contact

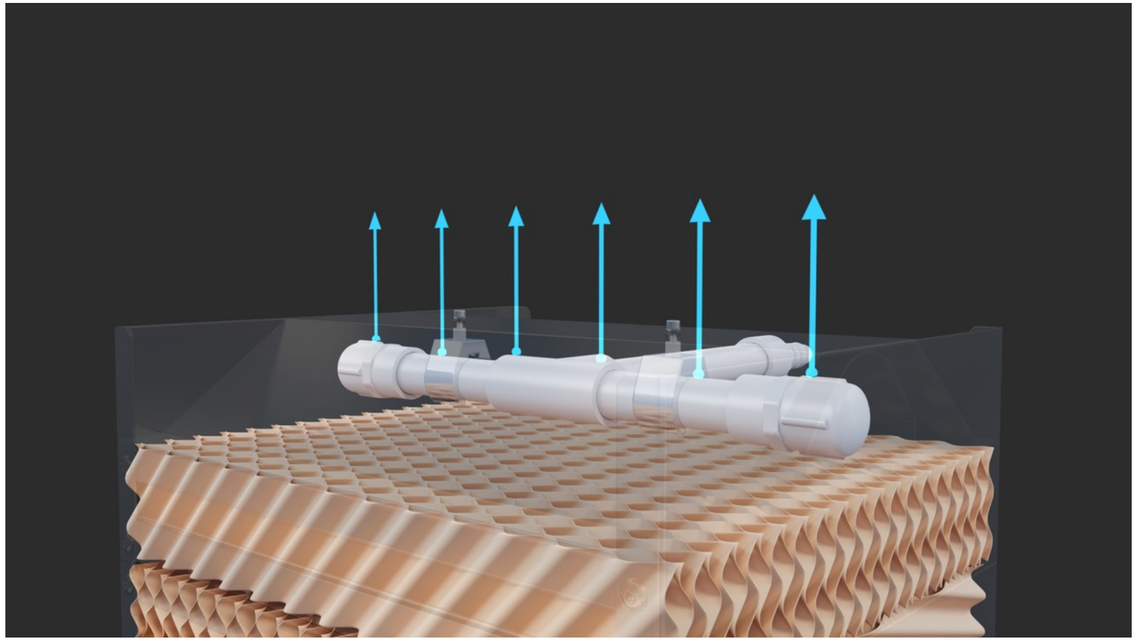


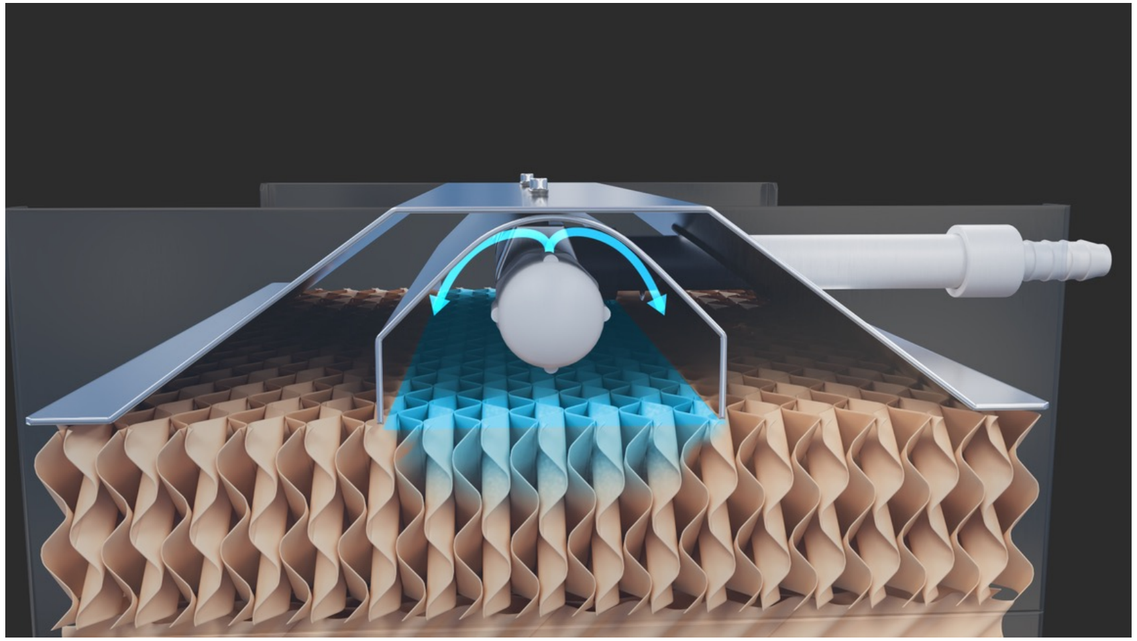
Water Flow



Air Flow

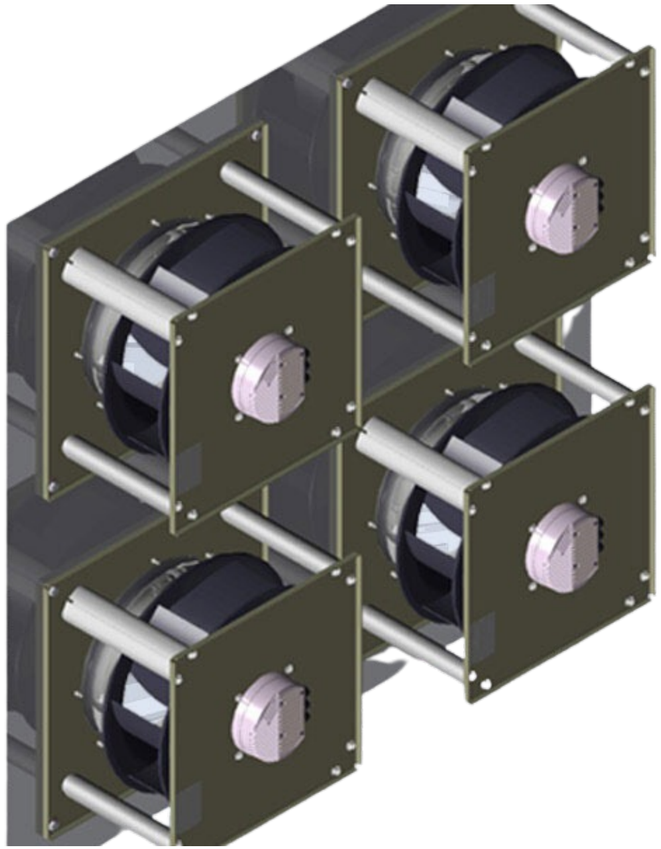
Water Supply and Distribution





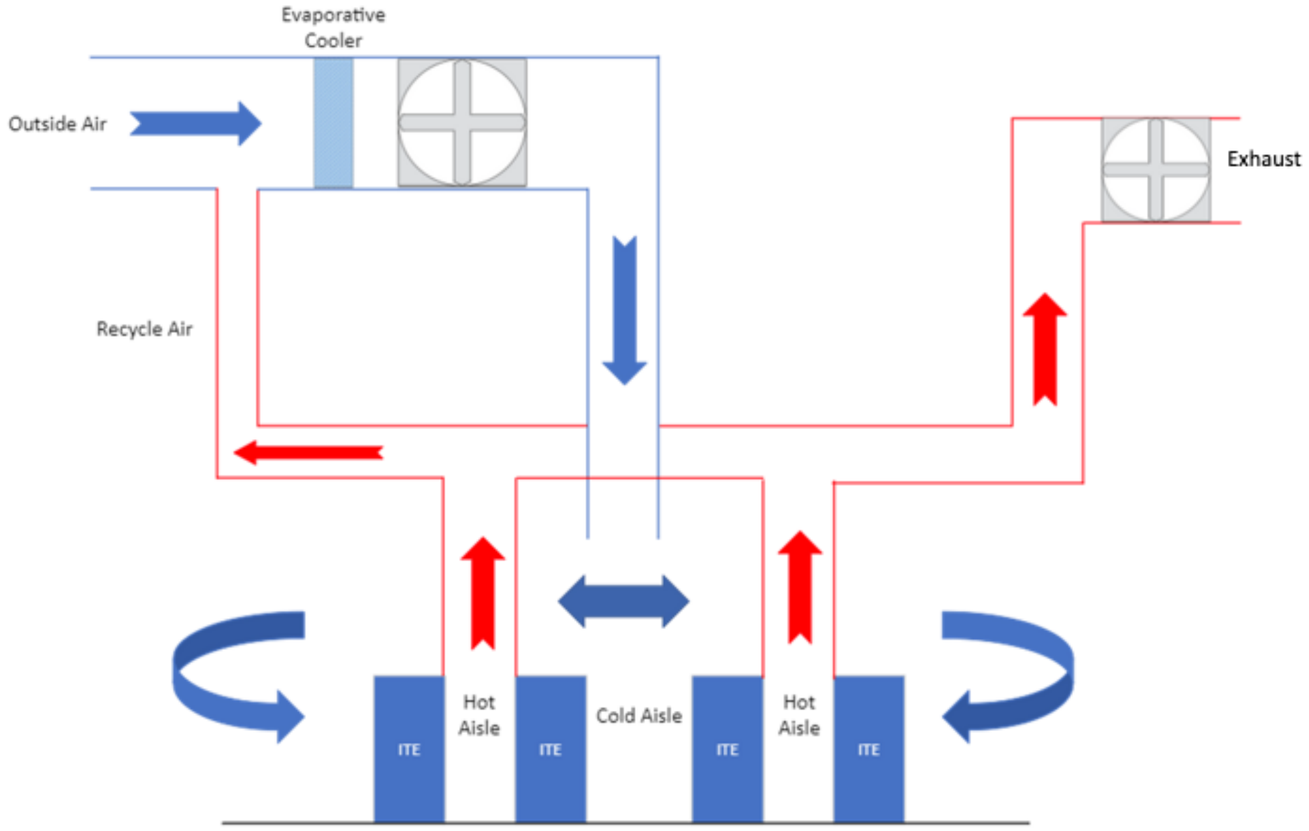
Air Delivery

- Fan Wall
- Axial Fan
- Square Cage Fan



Typical Data Center DEC System

- Cooled air is sent to cold aisles.
- Heated air is exhausted from the data hall.
- Hot air is recycled to maintain a minimum temperature.
- The evaporative cooler only runs when outside air exceeds the operating envelope.

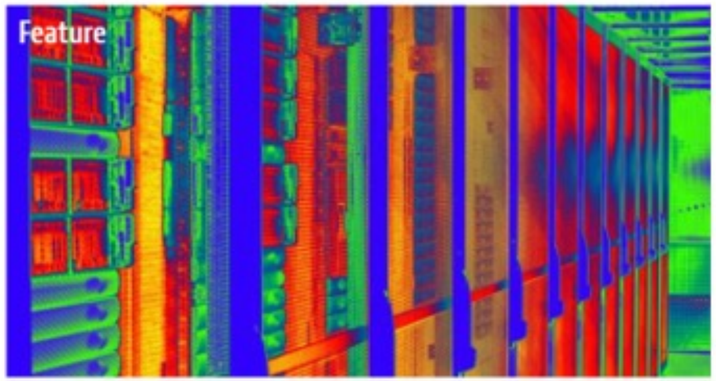


If all your friends raise their cold aisle temperature, would you?

XXX plans to slash the amount of water its data centers are using by implementing a system where sites will operate at higher temperatures but lower humidity.

XXX parent company said it has been trialing running some sites at 90 degrees Fahrenheit, around 5 degrees above their usual temperatures, as part of wider plans to become "water positive" by 2030.

Reducing water waste in data center operations by 95% by 2024: …Today, we're announcing a new approach to data center temperature management, which will further reduce the amount of water waste in our evaporative-cooled datacenters globally by 95% by 2024 – or an estimated 5.7 billion liters annually. Through our extensive global research on server performance in warmer temperatures, we're able to create higher set points for a variety of different climates for when water-based, evaporative cooling is necessary to preserve server performance and reliability.



COMPANIES >

Hot in Here: Is Raising Temperatures in Data Centers Good for Hardware?

plans to increase temperatures sparks debate, but if successful, the colocation provider could fuel an industry trend.

Wylie Wong | Jan 03, 2023

What do you wear in your data hall?

"Most organizations keep their data centers in the 68 to 71.6 degrees Fahrenheit (20 to 22 degrees Celsius) range" Data Center Knowledge 2023

"I get a pat on the back for saving power and water, but I get fired if the data center overheats."

Pre - TC9.9

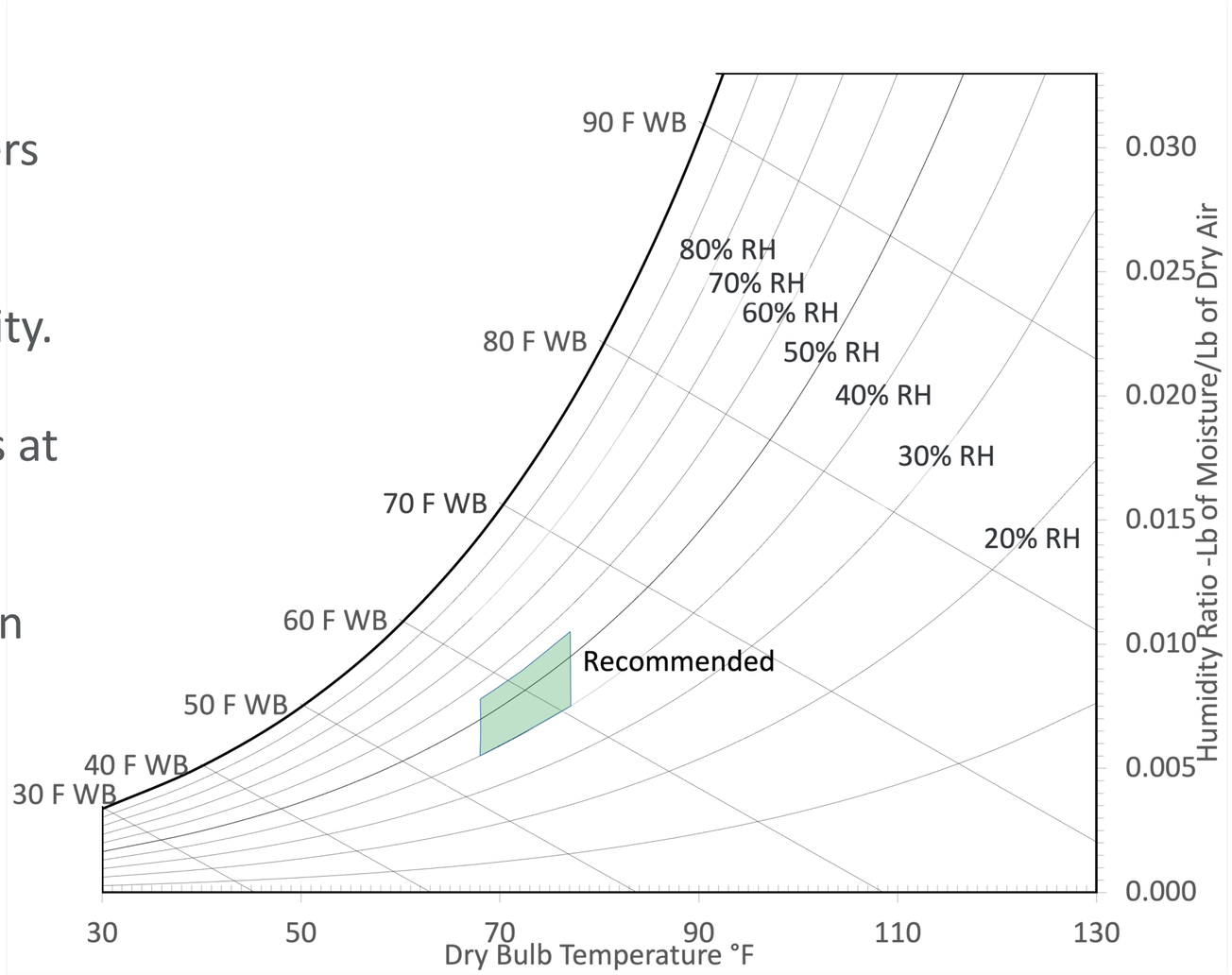
Current Recommended and Allowable Ranges

Operating Ranges

- Recommended Range – Server inlet temperatures should be within this range during most operating hours in a year
- Allowable Range – ITE manufacturers test their equipment to operate at these ranges.
- Actual Range – The range the facility and/or ITE operator decide on. Should be set based on the operator's evaluation of the lowest TCO or other metrics.

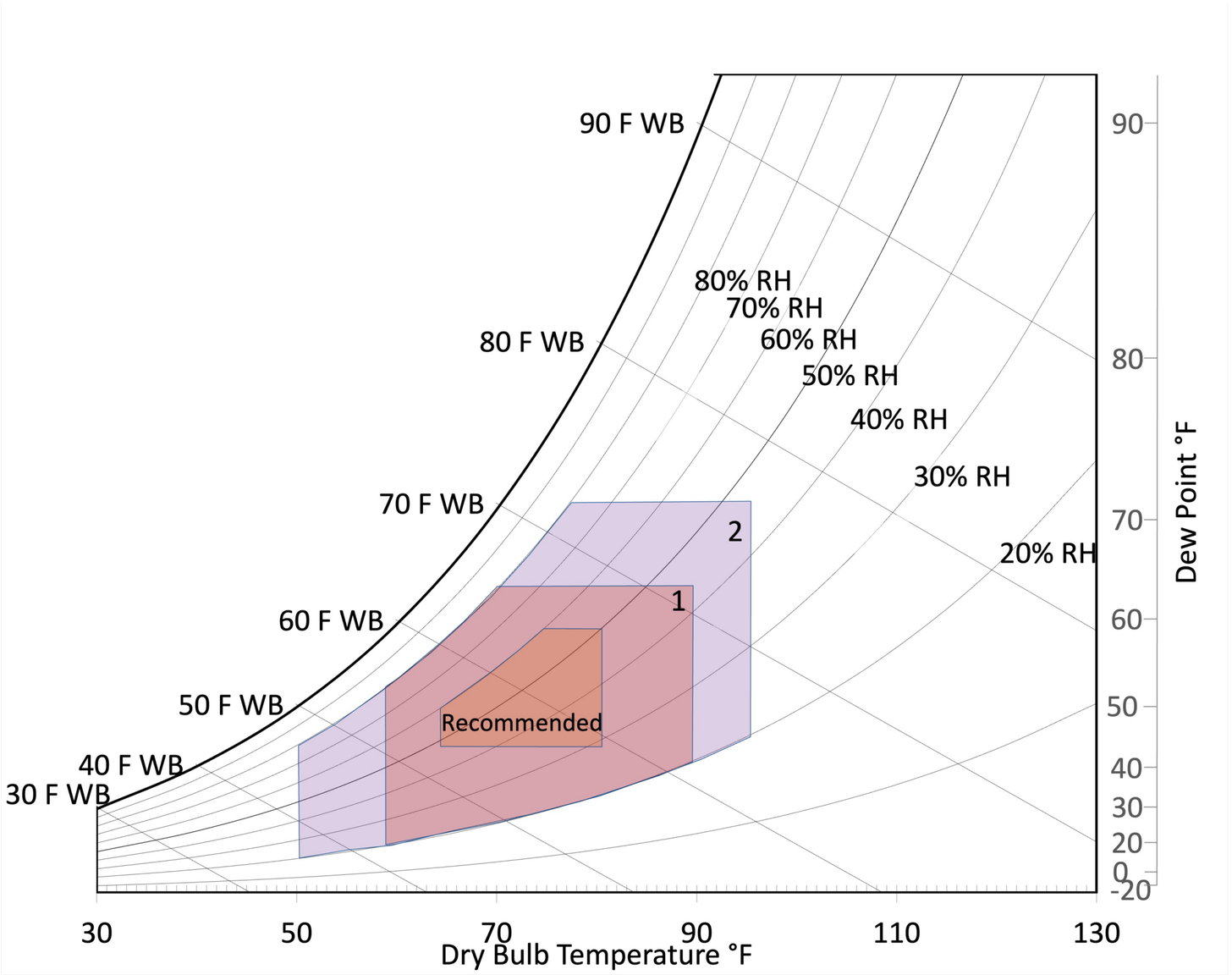
ASHRAE TC 9.9 Thermal Guidelines

- First released in 2004
- Goal of setting standards for hardware suppliers to meet.
- The desire was to maintain equipment reliability.
- Power and water efficiency were not the focus at that time.
- Established IT equipment air inlet as a common measurement point.
- Guidelines are managed by the ASHRAE Technical Committee 9.9



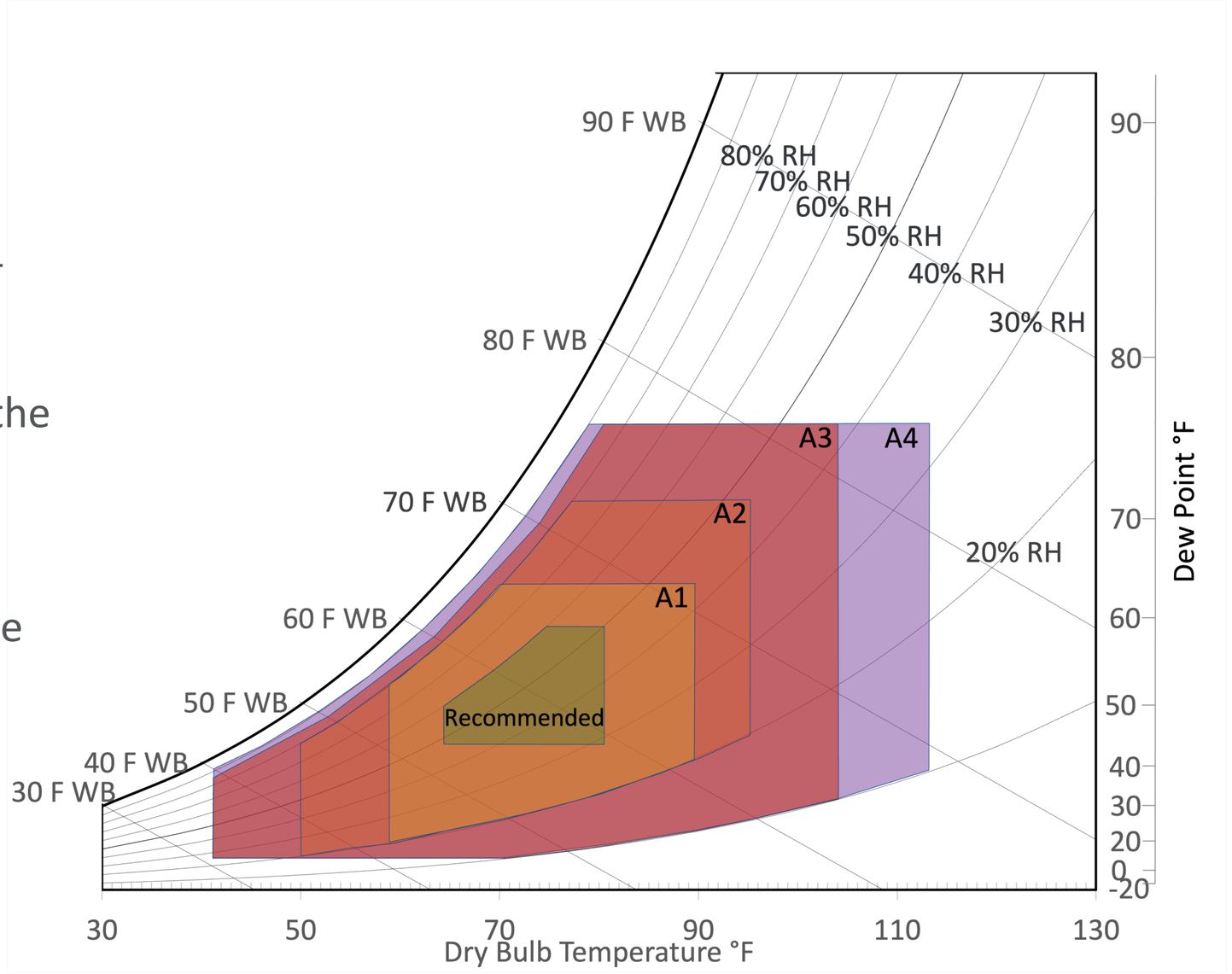
2008 Update

- Guidelines were updated in 2008.
- Classes 1 through 4 were added.
- Added dew point to the humidity limits.
- Start moving away from “cold is better” and increased economizer usage.
- Response to industry desire to optimize PUE.



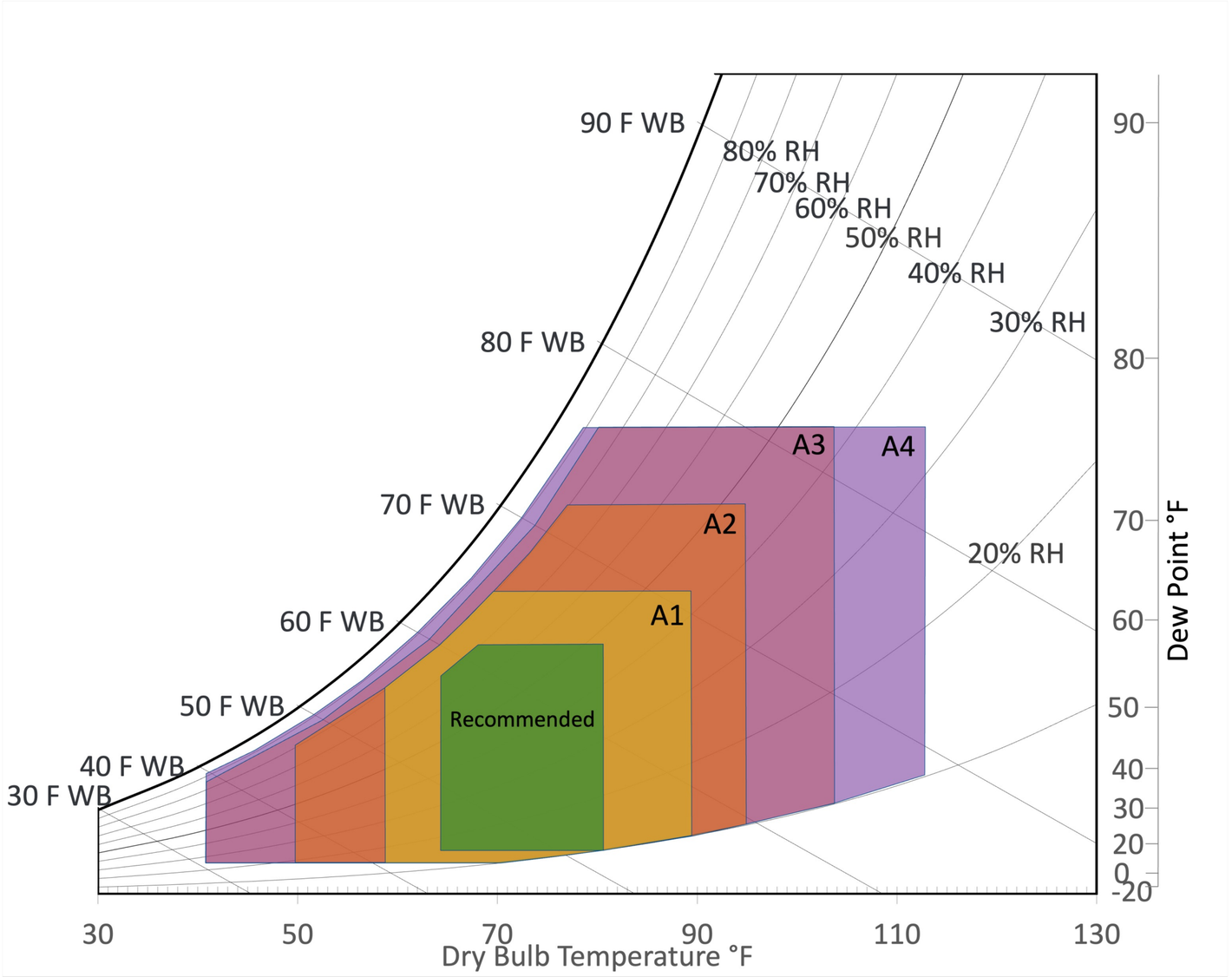
2011 Update

- Guidelines were updated again in 2011
- Classes 1 through 4 were changed to A1 through A4 and B/C
- Give operators more info to operate in the most efficient mode with maintaining reliability.
- A3/A4 ranges enabled near full-time free cooling in most climates.

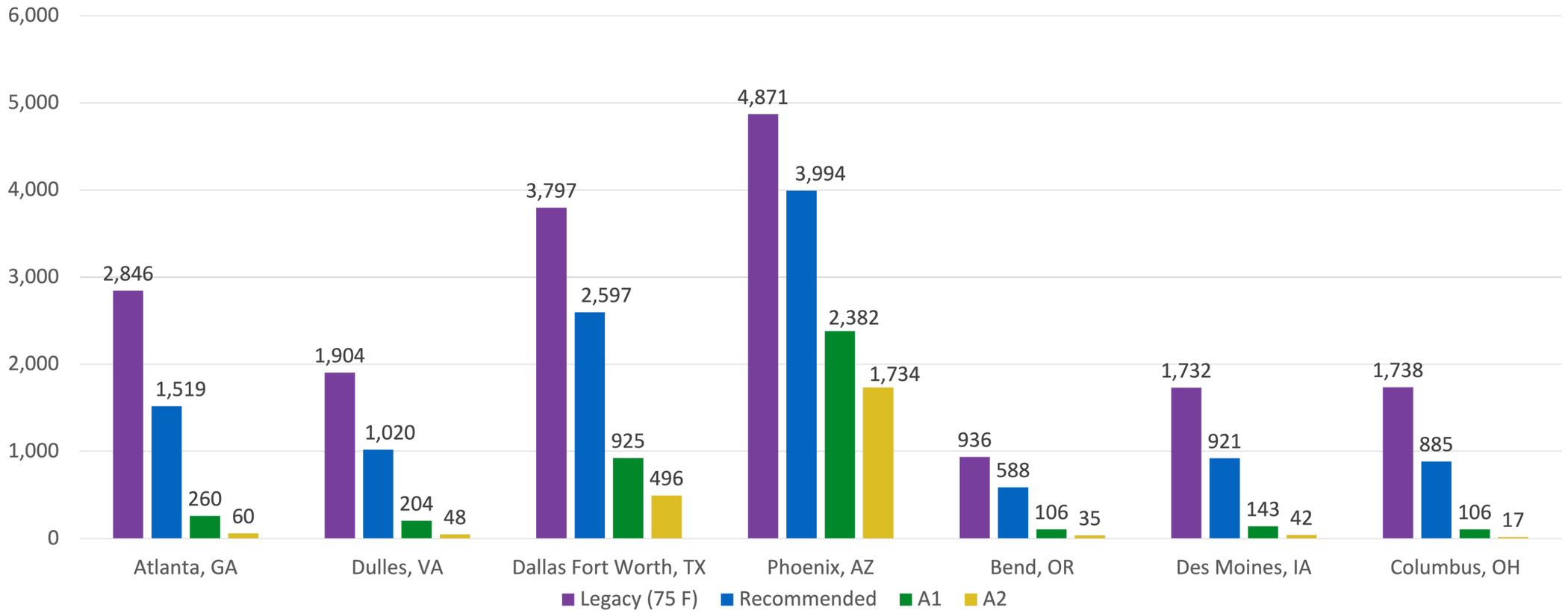


2015/2021 Updates

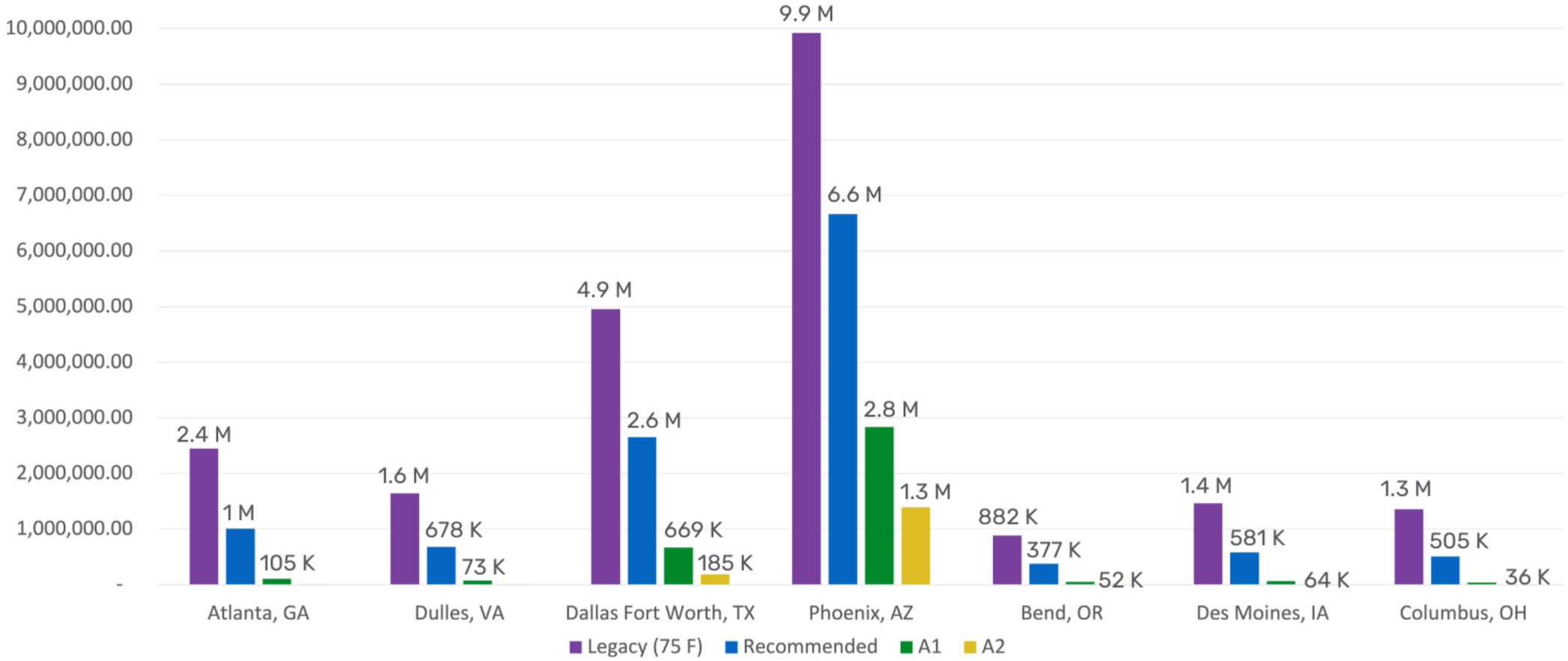
- 2015 expanded the humidity envelope.
- 8% RH for A1 and A2 classes.
- 15.8 F dew point
- 2021 added pollutants as a factor.
- Low levels of pollutants > recommended humidity limit.
- High levels of pollutants < recommended humidity limit.
- 2021 added high-density envelope.



Evaporative Cooling Hours / Year

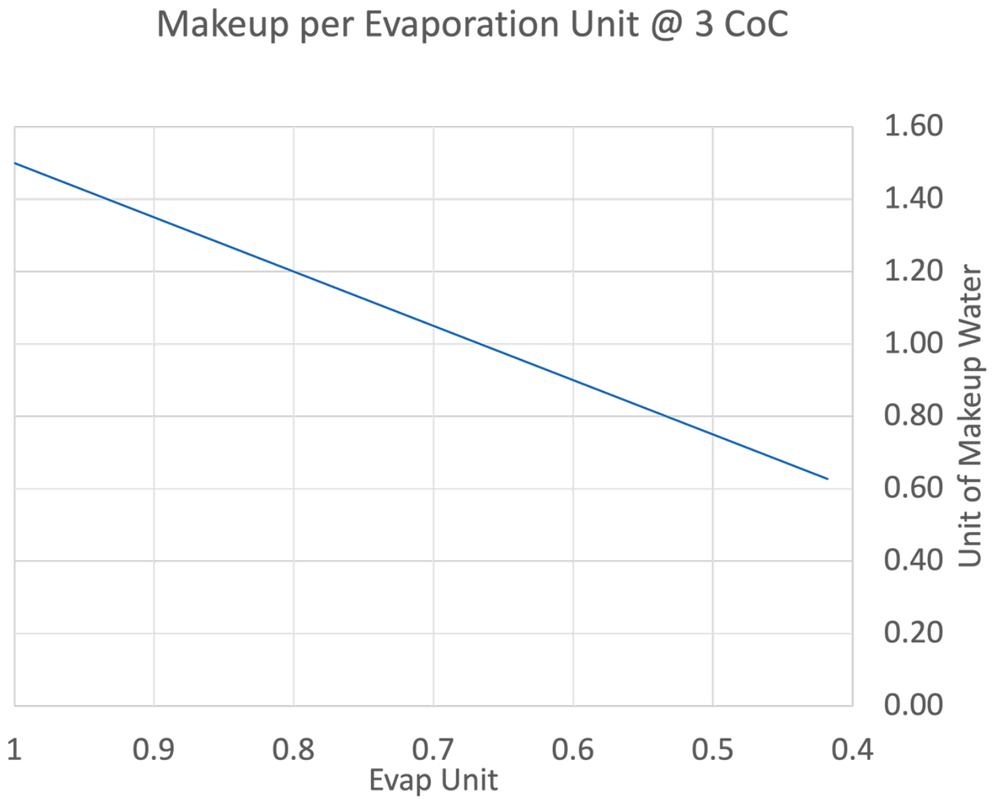


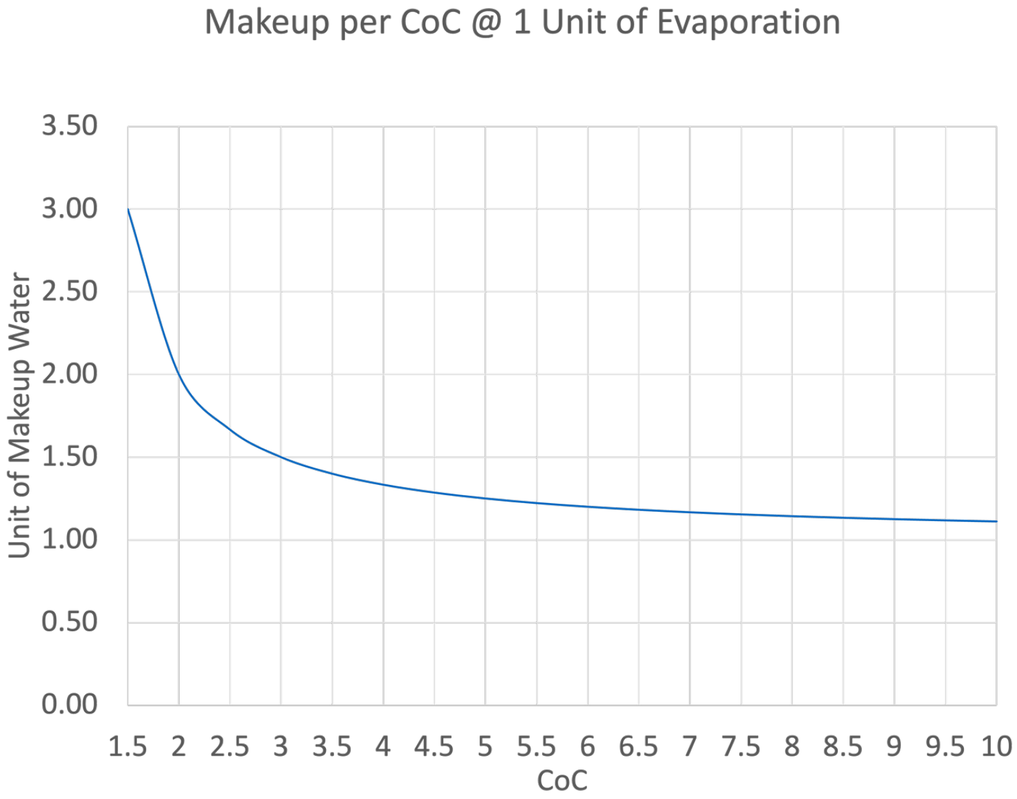
Evaporation Gallons / Year



(7.5 MW IT Capacity)

Water Reduction Options



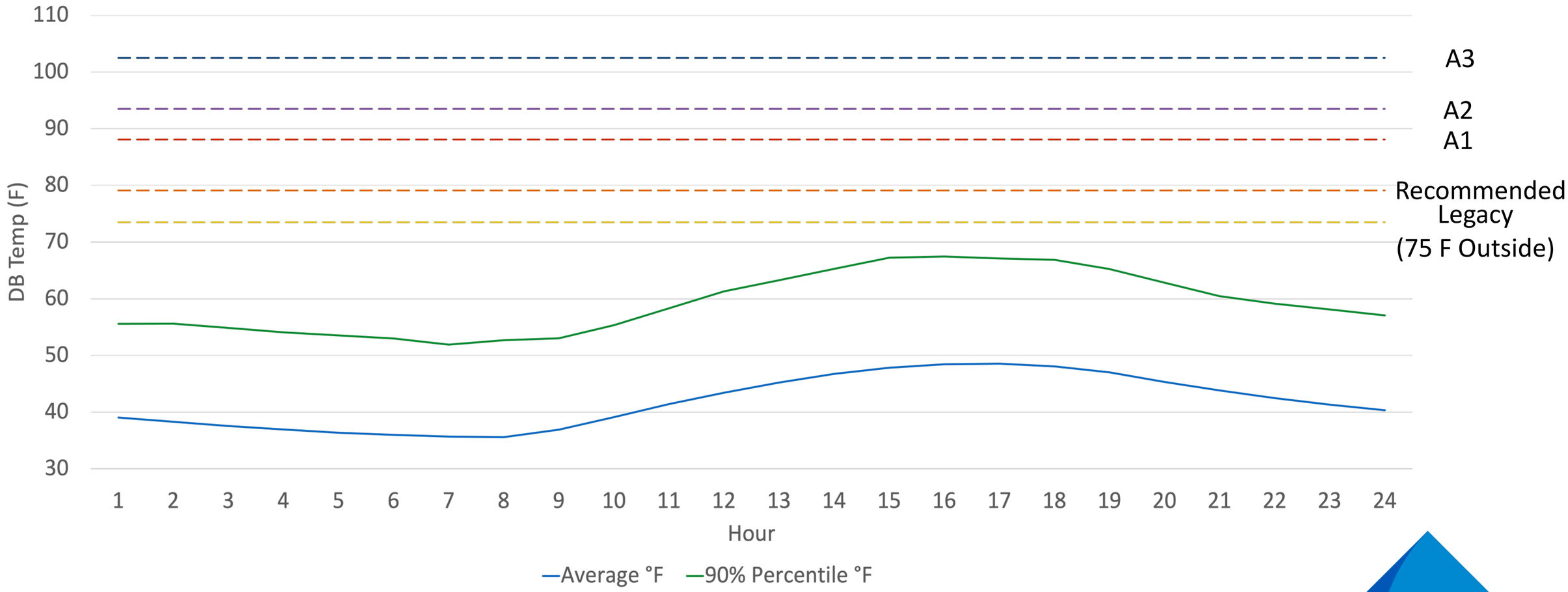


Columbus Ohio Example

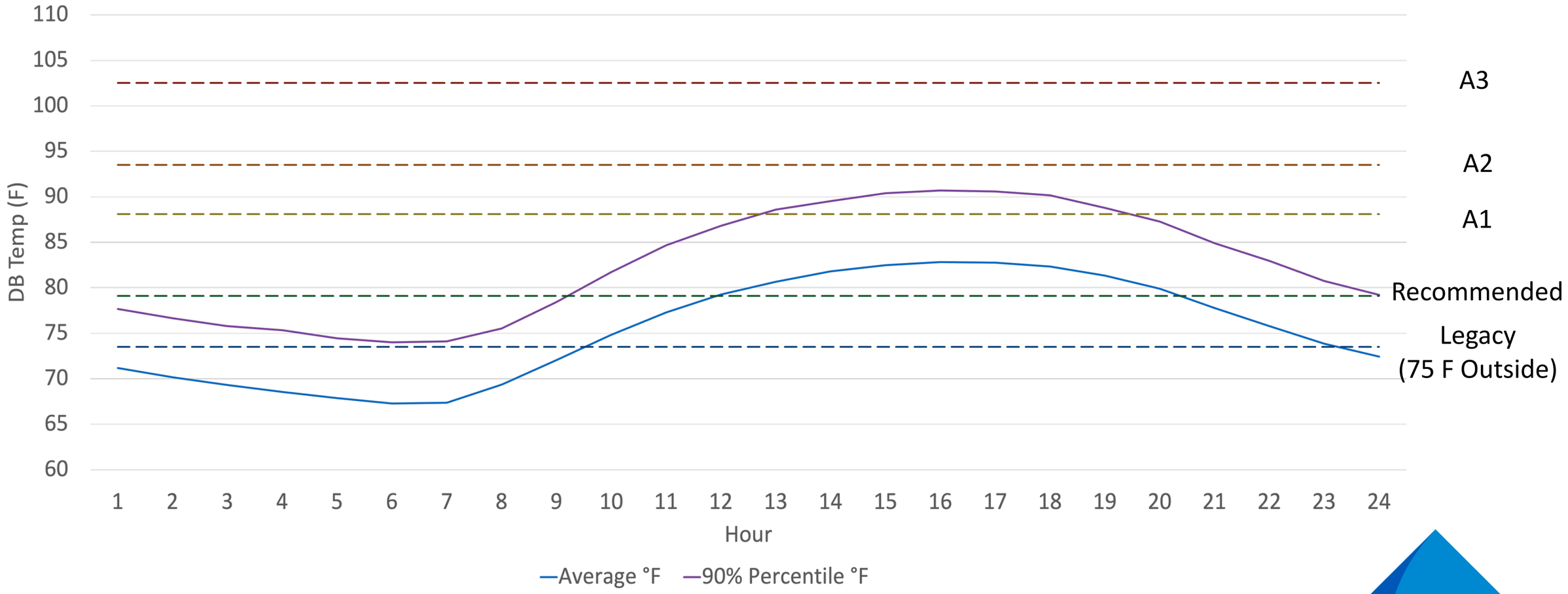
	Gallons per Year			Makeup Water % Reduction from Legacy	WUE	Cooling Hours
Class	Evaporation	Blowdown	Makeup			
Legacy (75 F)	1,356,757	678,378	2,035,135		0.1165	1,738
Recommended	505,148	252,574	757,723	63%	0.0434	885
A1	36,412	18,206	54,618	97%	0.0031	106
A2	2,253	1,127	3,380	99.8%	0.0002	17

- 7.5 MW IT Capacity
- CoC of 3

Columbus Ohio Daily Temperature - March

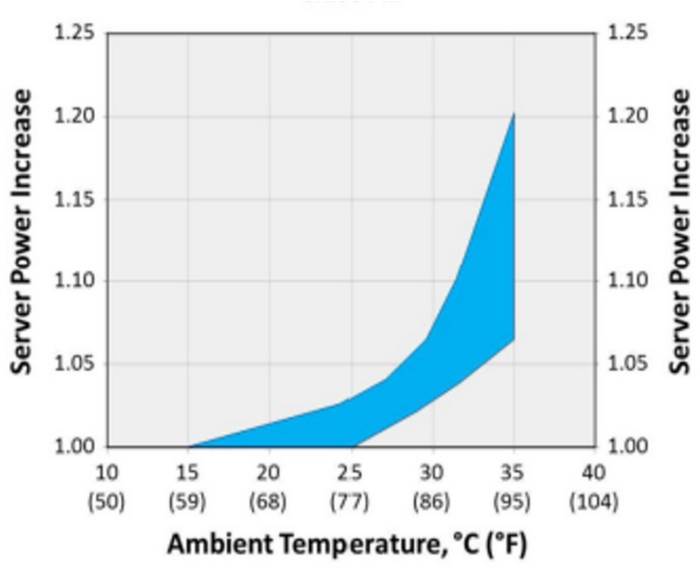


Columbus Ohio Daily Temperature - July

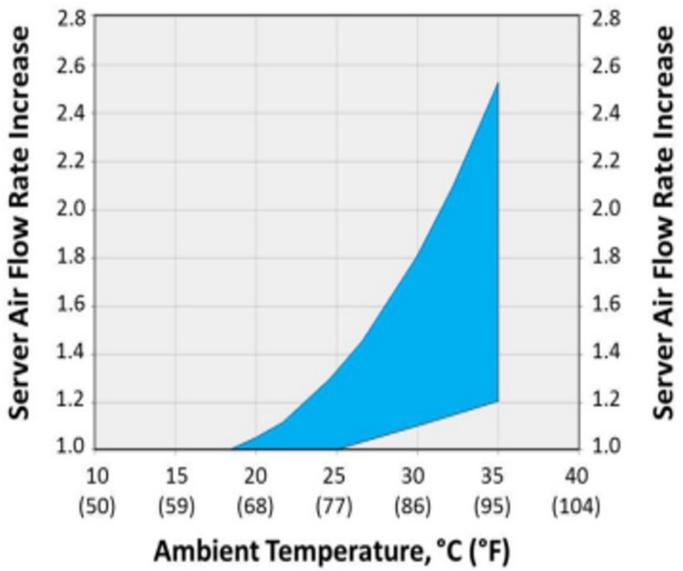


ITE Power Changes

- As server inlet temperature increases the ITE equipment power requirements increase.
- This is due to higher ITE fan speeds and leakage current in the processers



Server power increase vs. ambient temp increase



Server flow rate increase vs. ambient temp increase

Reference: ASHRAE Thermal Guidelines for Data Processing Environments

Facility Power Changes

- Facility power changes will be dependent on the control strategy utilized.
  - dP-based fan control
  - Cold aisle temperature control
- Increased power consumption will only be seen during hotter ambient conditions.
- Maximum efficiency will be achieved when cold aisle temperatures are allowed to vary throughout the day/year.
- Max fan speeds can be reset to higher temperature values.
- Reduced need for dehumidification.

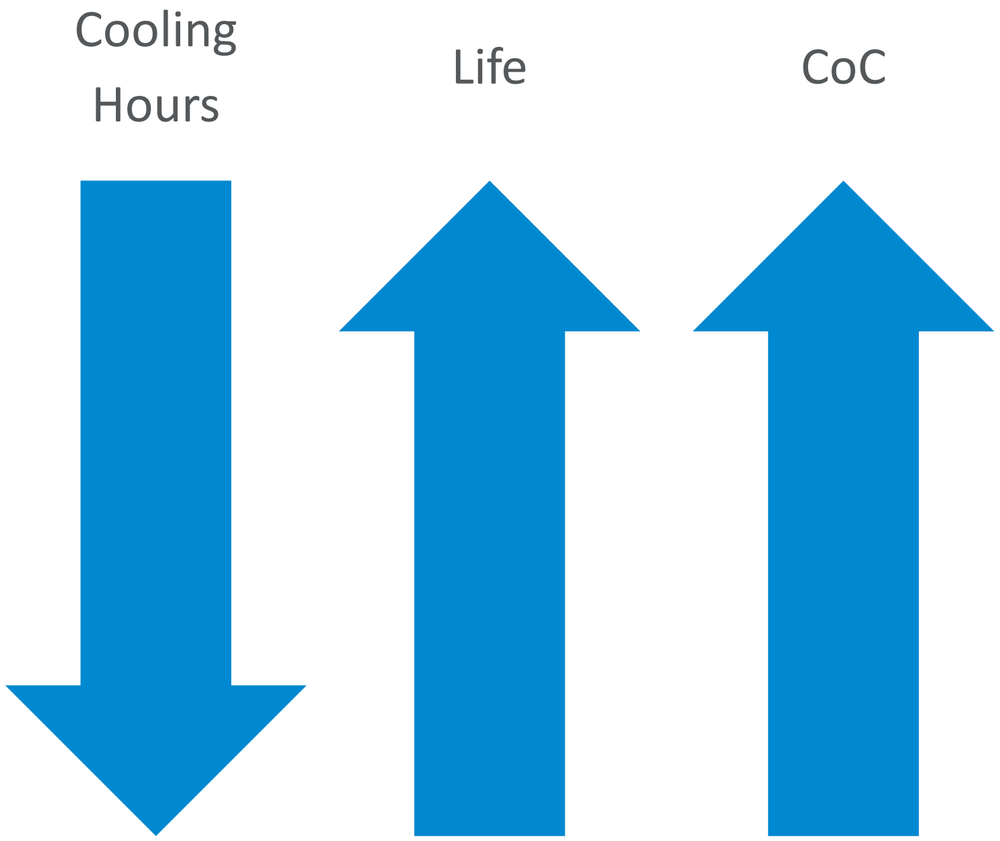
Server Reliability (X-Factor)

- Estimates relative failure rate at different temperatures.
- Increase in the rate of failed servers, not the percentage of total server failures.
- Baselined off of 68F.
- Represents continuous operation at that temperature.
- Time-weighted average required to assess true reliability.
- Does not account for air phase pollutants.

- Columbus, Ohio (A3 Allowable)
  - >6000 hours outside air < 68 F
  - Time-weighted x-Factor <1
- Time-weighted x-Factor = 1.4
  - Baseline 5 failures per 1000 at 68 F
  - Failures increase to 8 per 1000

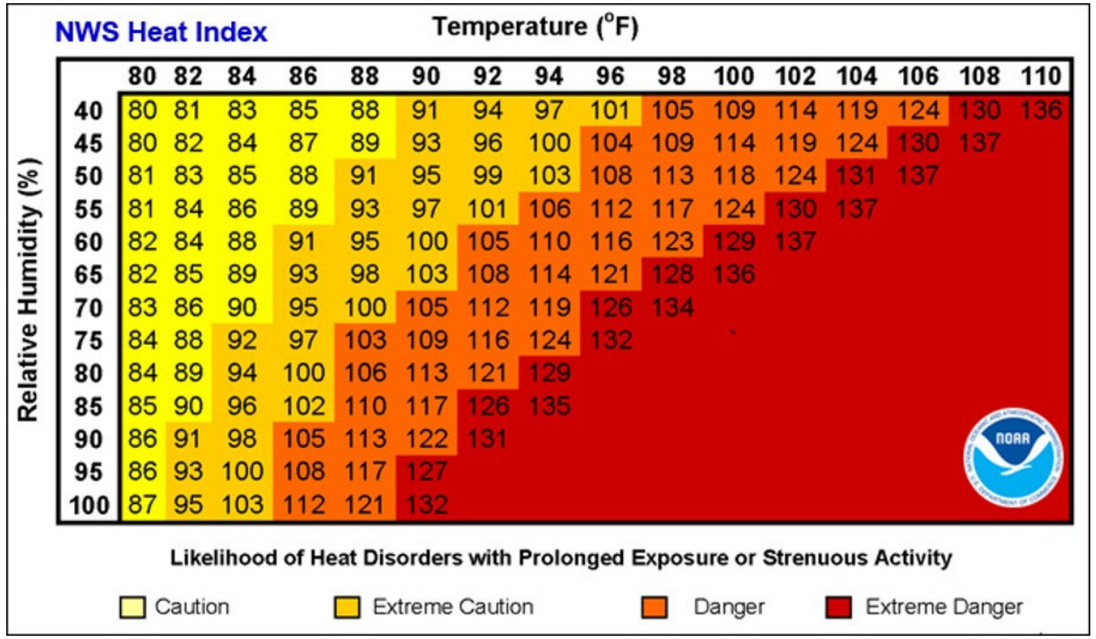
Media Life

- Media life is most affected by hours of wetted use.
- Reducing the wetted hours will increase media life under equal water conditions.
- Reducing wetted hours can allow for more aggressive water conditions



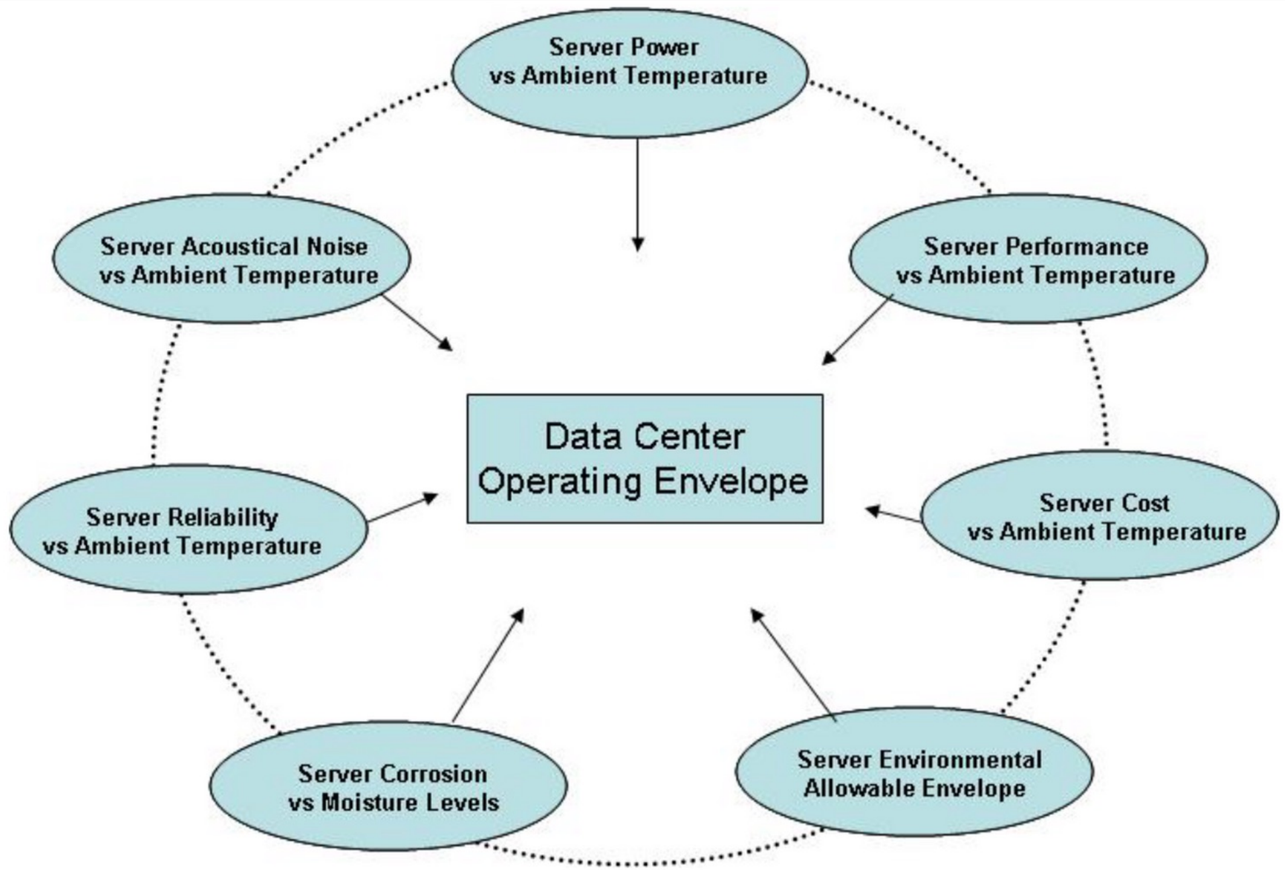
Personnel Concerns

- Hotter/humid conditions can affect site working conditions.
- Increased temperature ranges may result in a noise increase from fans operating at a higher capacity.
- EHS stakeholders should be engaged as part of temperature changes.



Final Thoughts

- All factors must be considered
- Implementation of thermal best practices
  - Containment, VFDs, and temp control on the control system
- Leverage guidelines included in ASHRAE publications.
- Include a wide range of stakeholders
  - EHS, Facilities Engineering, Operations, Hardware Engineering



Server metrics for determining data center operating environment envelope

Reference: ASHRAE Thermal Guidelines for Data Processing Environments

Questions

Additional questions can be sent to
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