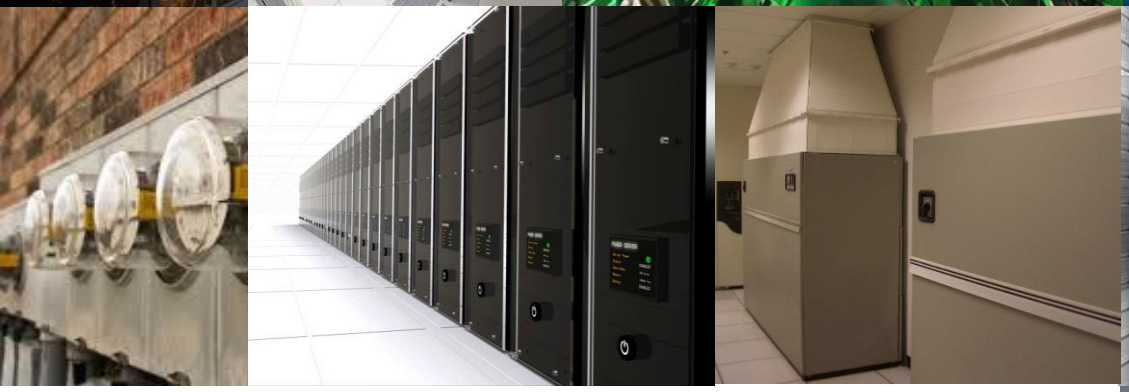



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Environmental Conditions for Data Centers

Data Center Optimization Initiative Webinar

November 1, 2017

Steve Greenberg, P.E.

Lawrence Berkeley National Laboratory

FEMP Federal Energy Management Program

Version: 10/27/2017

Download Presentation

This Presentation is Available for download at:

http://datacenterworkshop.lbl.gov/

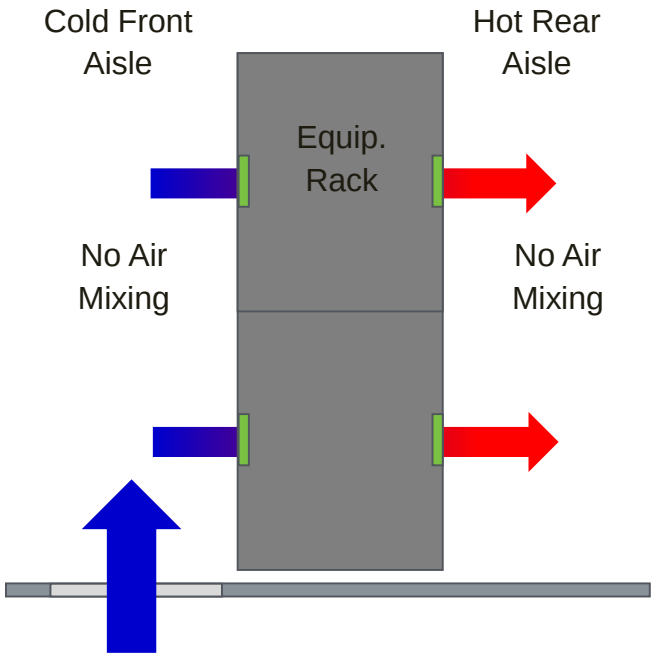
Agenda

- Air Management review
- Data center environmental conditions
- Cooling System savings from better air management and improved environmental conditions

Air Management Review

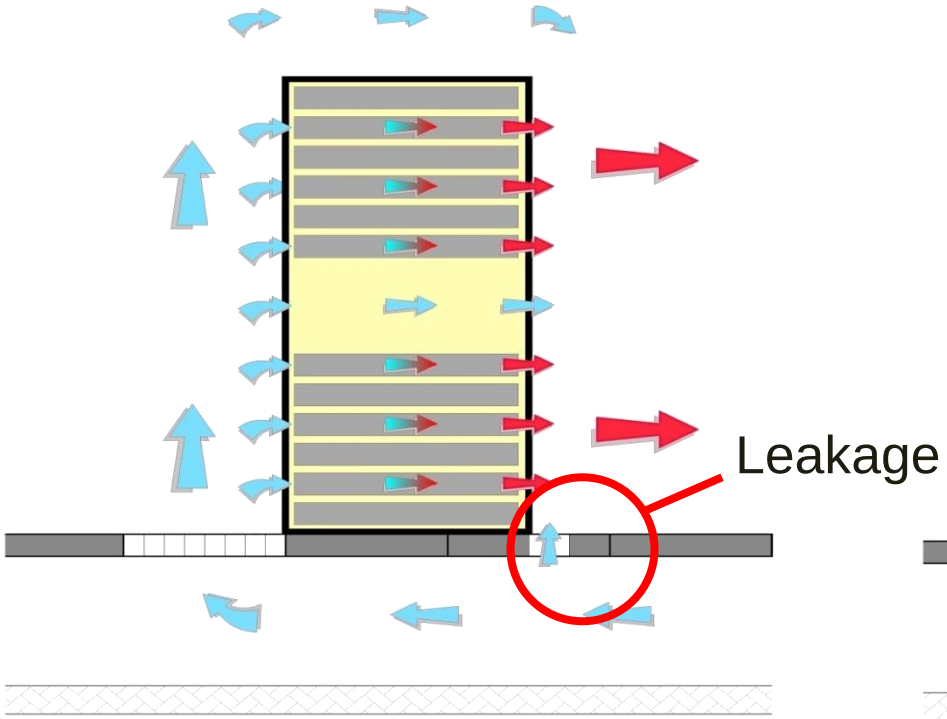
Separating Cold from Hot Airflow

- Supply cold air as close to the rack inlet as possible
- Reduce mixing with ambient air and hot rack exhaust
- Air moves from the front cold aisle to the rear hot aisle



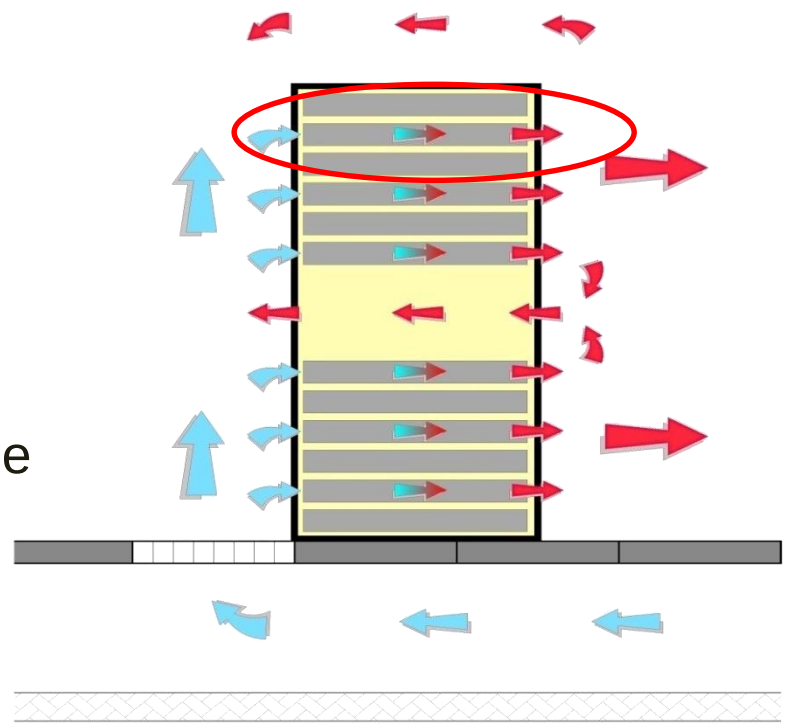
Reduce By-Pass and Recirculation Air

Bypass Air / Short-Circuiting



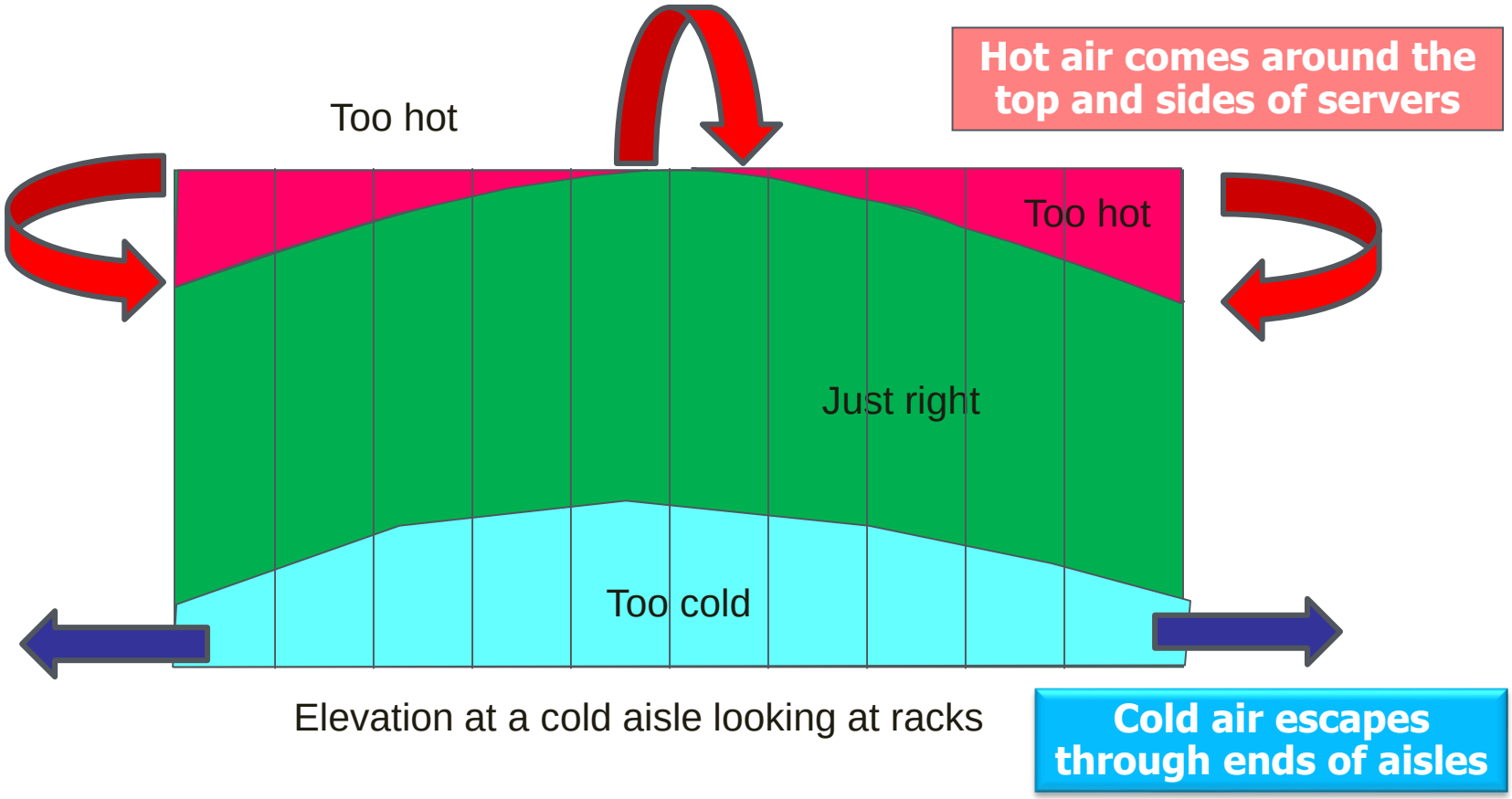
Wastes fan energy as well as cooling energy and capacity

Recirculation



Increases inlet temperature to servers

Typical Temperature Profile with Under-floor Supply

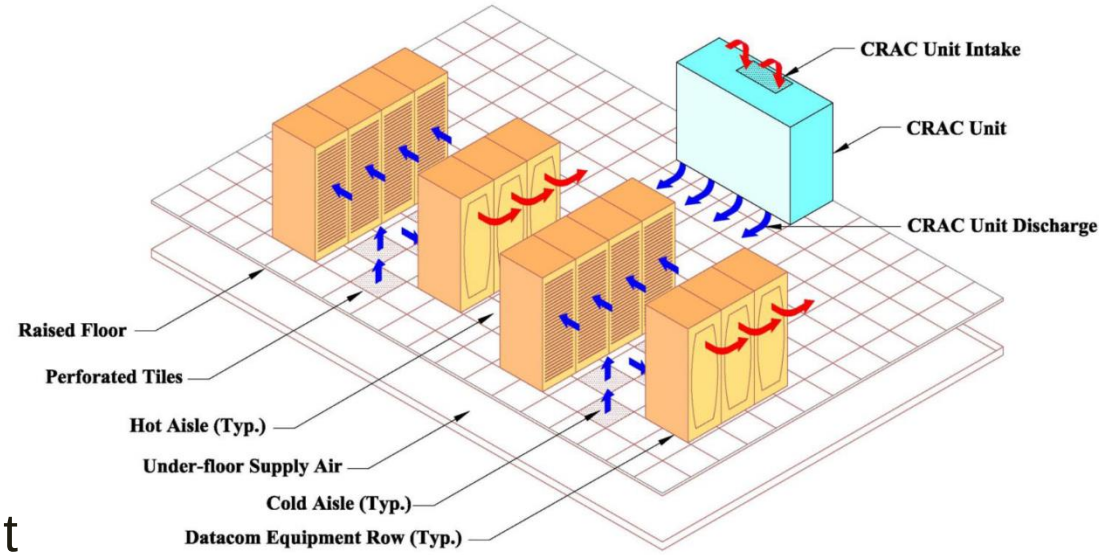


There are numerous references in ASHRAE.
See for example V. Sorell et al; “Comparison of Overhead and Underfloor Air Delivery Systems in a Data Center Environment Using CFD Modeling”; ASHRAE Symposium Paper DE-05-11-5; 2005.

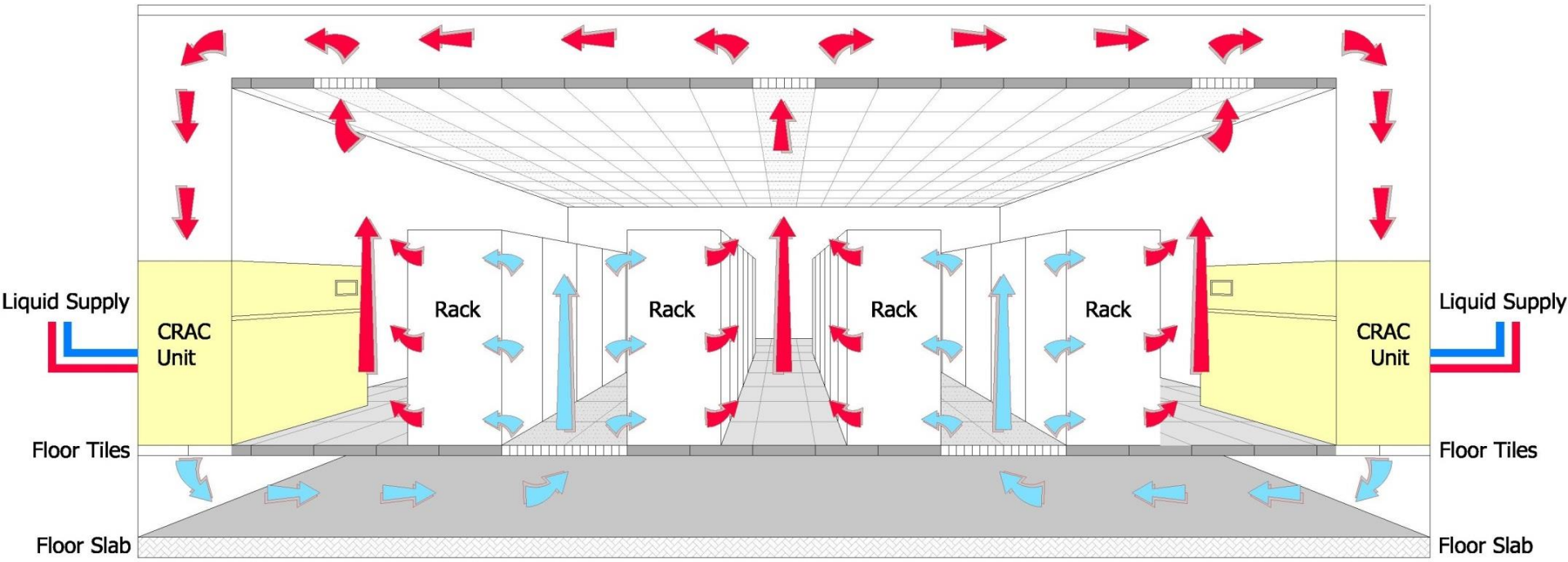
Hot- and Cold-aisles

- Improves equipment intake air conditions by separating cold from hot airflow

- Preparation
  - Arrange racks with alternating hot and cold aisles
  - Supply cold air to front of facing servers. Hot exhaust air exits into rear aisles.

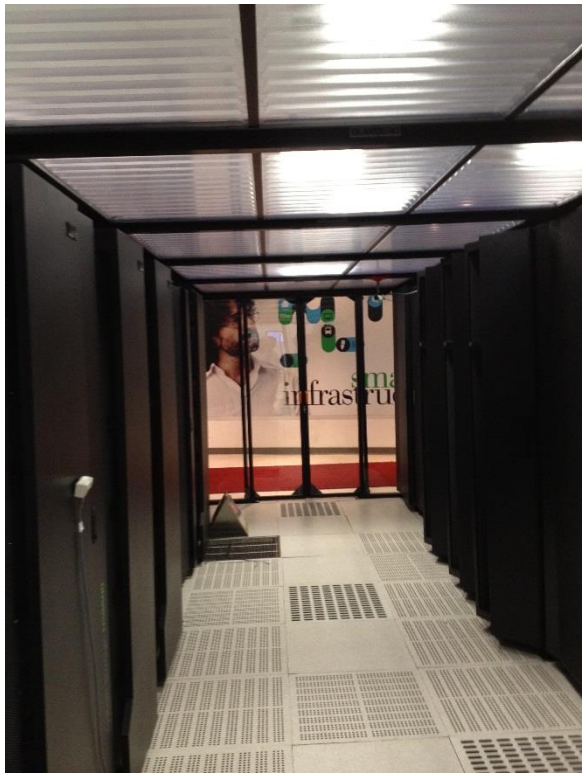


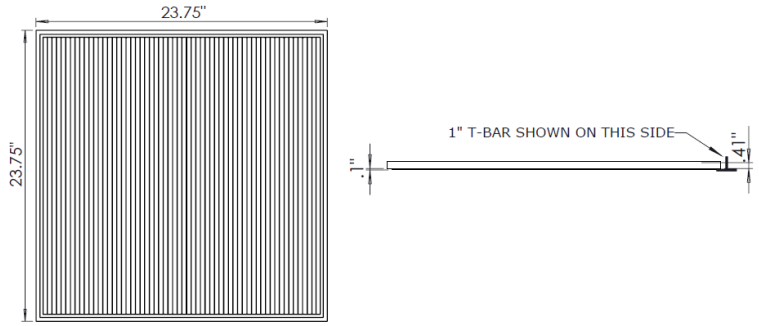
Next step: Air Distribution Return-Air Plenum



Hot and Cold Aisle Containment

Subzero Cold Aisle Containment





APC Hot Aisle Containment
(with in-row cooling)

Ceilume Heat Shrink Tiles

Airflow Management Review

Air management techniques:

- Seal air leaks in floor (e.g., cable penetrations)
- Prevent recirculation with blanking panels in racks and between racks
- Manage floor tiles (e.g., no perforated tiles in hot aisle)
- Improve isolation of hot and cold air (e.g., return air plenum, curtains, or complete isolation)

Impact of good isolation:

- Supply airflow reduced
  - Fan savings up to 75%+
- Supply air temperature can be raised
  - Chiller efficiency improves
  - Greater opportunity for economizer operation (“free” cooling)
- Cooling and raised-floor capacity increases.

Environmental Conditions

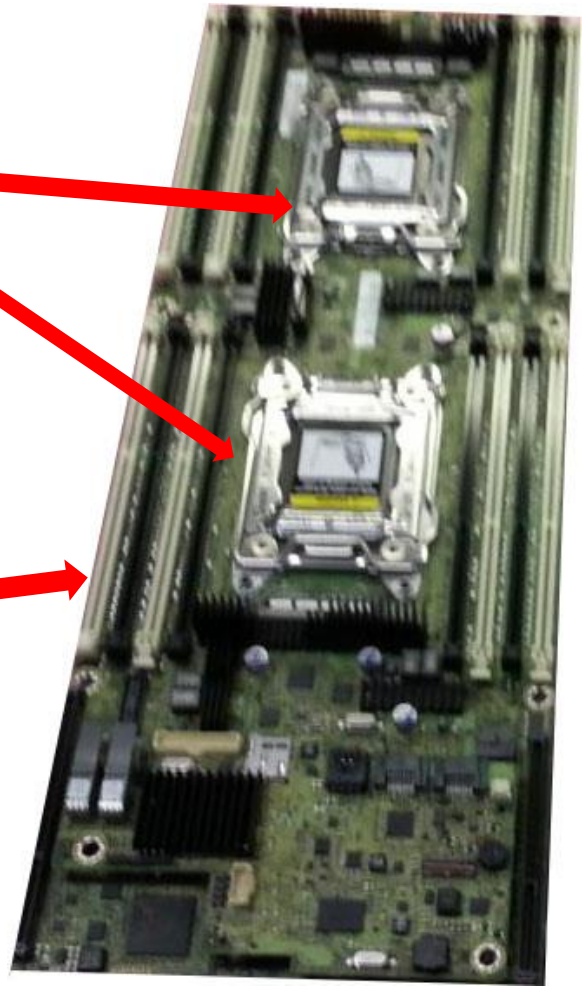
Environmental Conditions

What are the main HVAC Energy Drivers?

- IT Load
- Climate
- System Design
- Room temperature and humidity
  - Most data centers are overcooled and their humidity control is too tight
  - Human comfort should not be a driver

Safe Temperature Limits

CPUs
~65C
(149F)



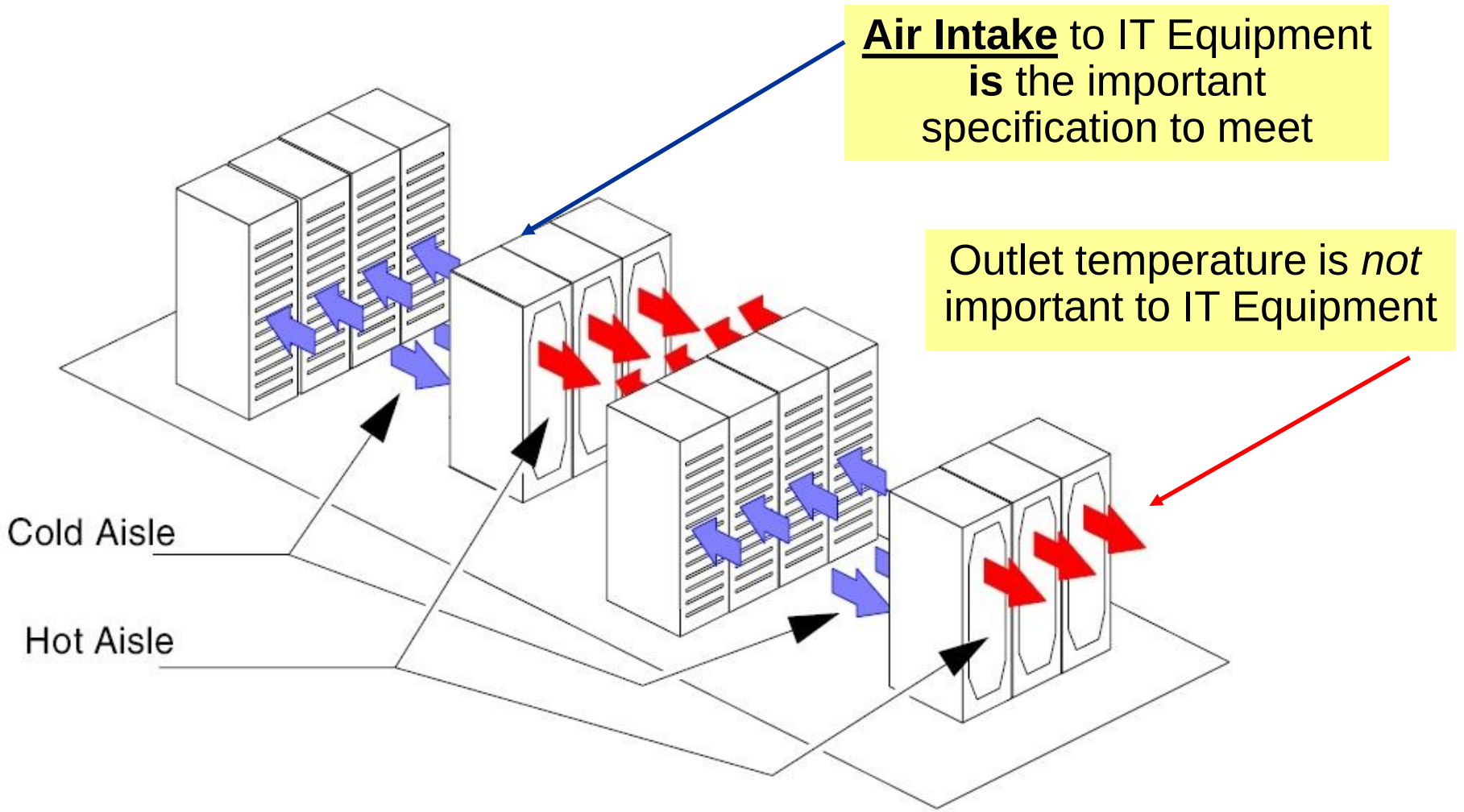
GPUs
~75C
(167F)

Memory
~85C
(185F)

So why do we need jackets in many data centers?

CPU, GPU & Memory, represent ~75-90% of heat load

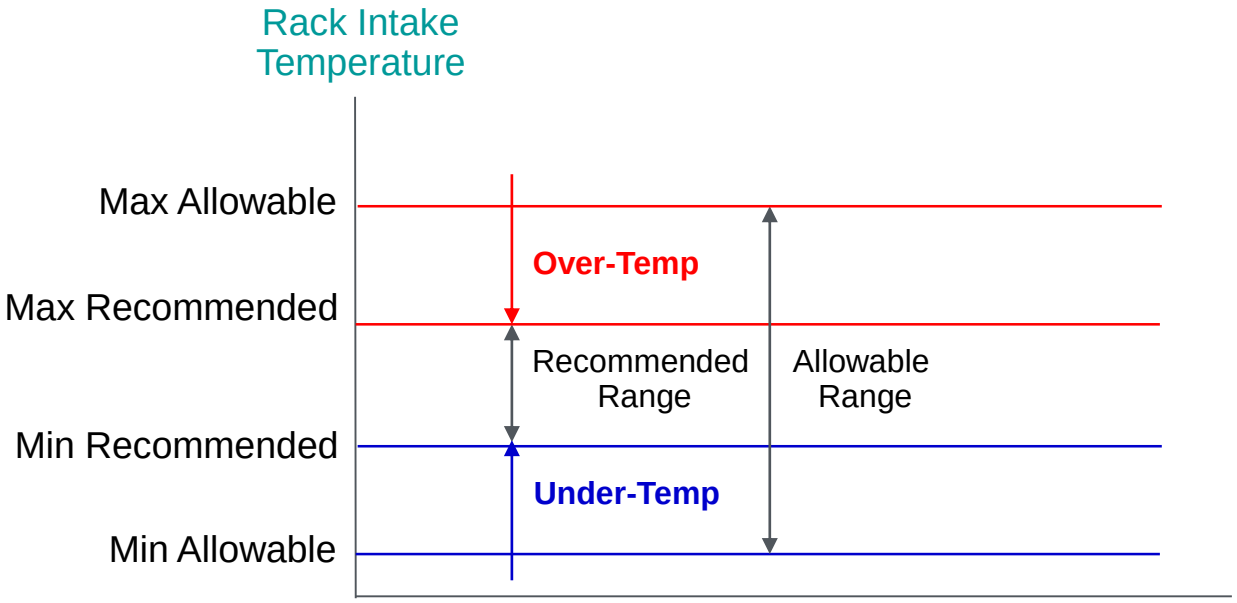
Equipment Environmental Specification



Key Nomenclature

- The recommended range is a statement of reliability. For extended periods of time, the IT manufacturers recommend that data centers maintain their environment within these boundaries.

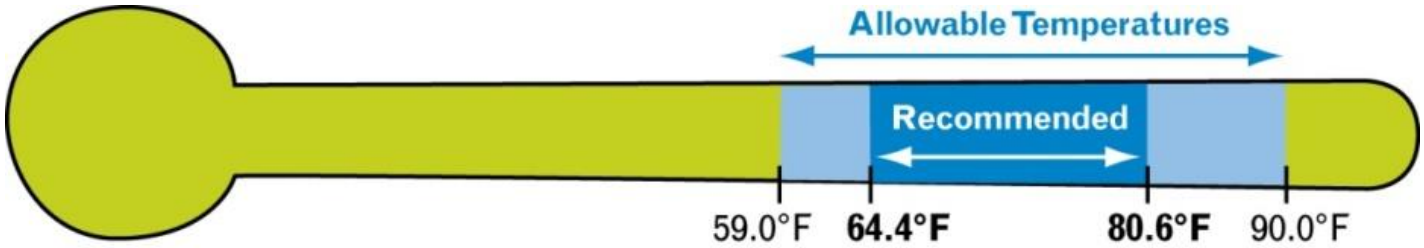
- The allowable range is a statement of functionality. These are the boundaries where IT manufacturers test their equipment to verify that the equipment will function.



ASHRAE Thermal Guidelines

- Default recommended range = 64.4 - 80.6F
- Provides guidance for operating above the default upper limit

- Default allowable range = 59.0 – 89.6F (Class A1)
- Six classes with allowable ranges up to 113.0F



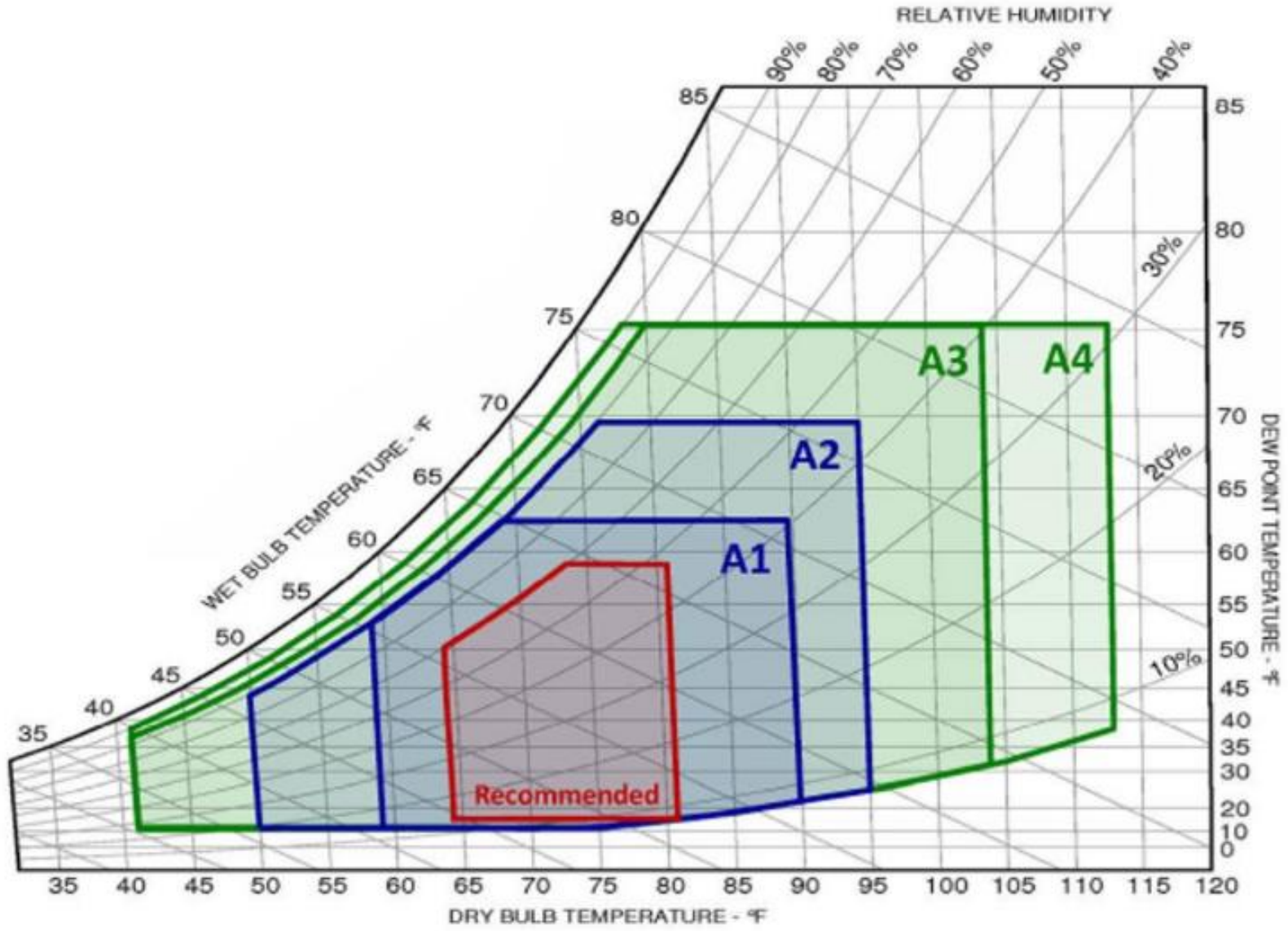
Recommended Data Center Environmental Conditions

ASHRAE 2015 (partial):

Class	Dry Bulb (°F)	Humidity Range	Maximum Dew Point (°F)	Maximum Elevation (ft)	Maximum Rate of Change (°F/hr)
Recommended					
A1 to A4	64.4 to 80.6	15.8°F DP to 59°F DP and 60% RH	N/A		
Allowable					
A1	59 to 89.6	10.4°F DP and 8% RH to 62.6°F DP and 80% RH	62.6	10,000	9*/36
A2	50 to 95	10.4°F DP and 8% RH to 69.8°F DP and 80% RH	69.8	10,000	9*/36
A3	41 to 104	10.4°F and 8% RH to 75.2°F DP and 85% RH	75.2	10,000	9*/36
A4	41 to 113	10.4°F DP and 8% RH to 75.2°F DP and 90% RH	75.2	10,000	9*/36

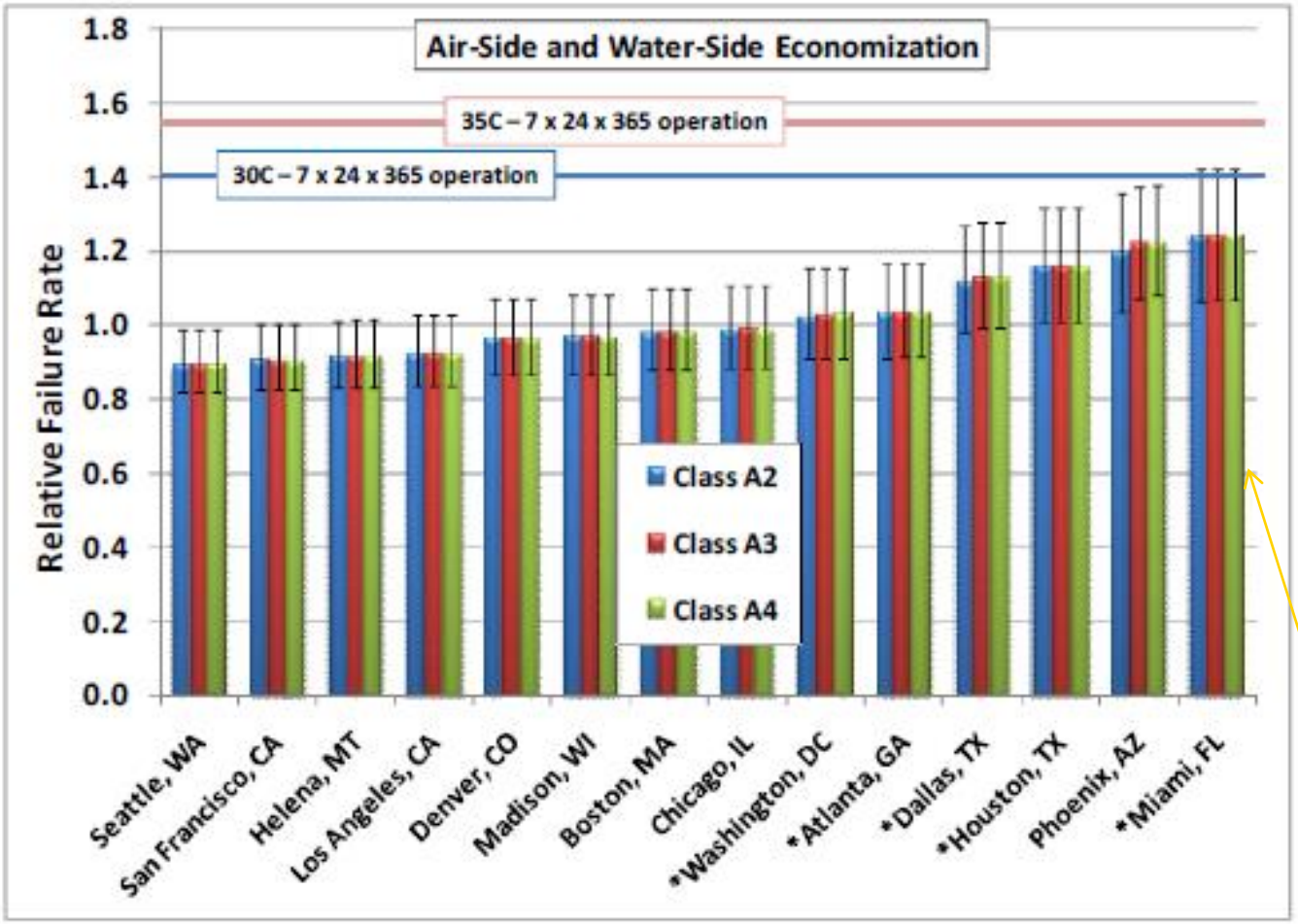
*More stringent rate of change for tape drives

2015 ASHRAE Allowable Ranges



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Thermal Conditions Are Less Relevant



Source: ASHRAE

If 4 failures per 1,000 servers incorporates warmer temperatures, and the relative failure. Rate is 1.2, then the expected failure rate would be 5 failures per 1,000 servers.

2015 ASHRAE Thermal Guidelines

ASHRAE's key conclusion when considering potential for increased failures at higher (allowable) temperatures:

"For a majority of U.S. and European cities, the air-side and water-side economizer projections show failure rates that are very comparable to a traditional data center run at a steady-state temperature of 20°C (68°F)."

Improve Humidity Control

- Eliminate inadvertent dehumidification
  - Computer heat load is sensible only
- Use ASHRAE allowable RH and temperature ranges
  - Many manufacturers allow even wider ranges
- Defeat equipment “fighting”
  - Coordinate controls (central)
  - Disconnect and only control humidity of makeup air, or
  - Control with one CRAC/CRAH unit
- Entirely disconnect (many have)

High-Humidity Limit Issues

- Contaminants (e.g., hygroscopic salts)
- Gaseous contamination
  - More study is needed in this area; however, few locations have such condition
- Particulates
  - Normal building filtration is effective in removing “enough” particulates

Low-Humidity Limit Issues

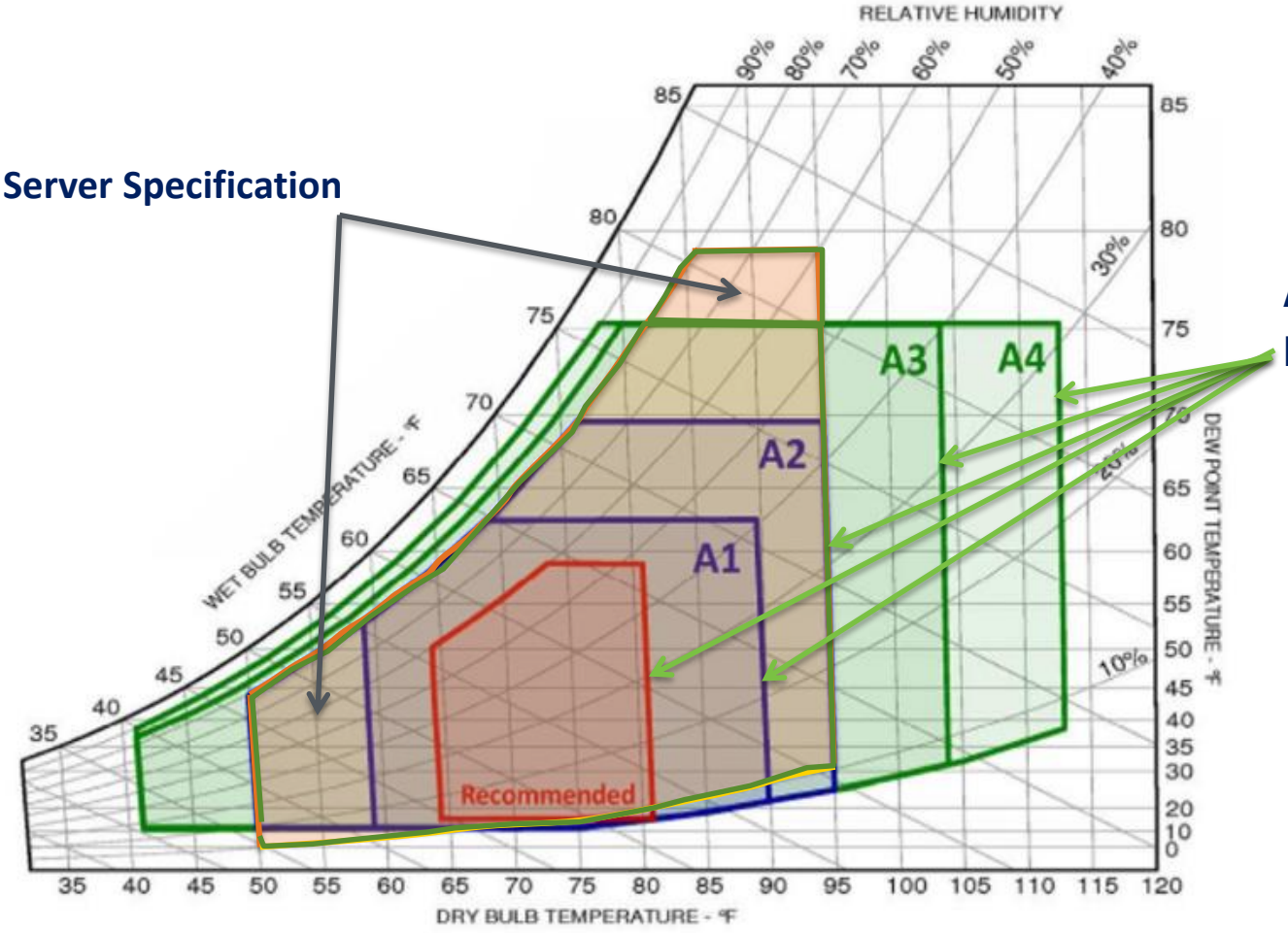
Electrostatic Discharge (ESD)

- Industry practices
  - Telecom has no lower limit (personnel grounding expected)
  - Electrostatic Discharge Association removed humidity control as a primary ESD control measure in ESD/ANSI S20.20
  - IT equipment is qualified to withstand ESD, and it is grounded
  - Many centers eliminate humidification with no adverse effects.

- Recommended procedures
  - Personnel grounding
  - Cable and floor grounding.

Not to Worry

Server Performance Specifications Generally Exceed ASHRAE Ranges



Courtesy ASHRAE and Dell

2014 ASHRAE Liquid Cooling Guidelines

- ASHRAE and a DOE High Performance Computer (HPC) user group developed guidance

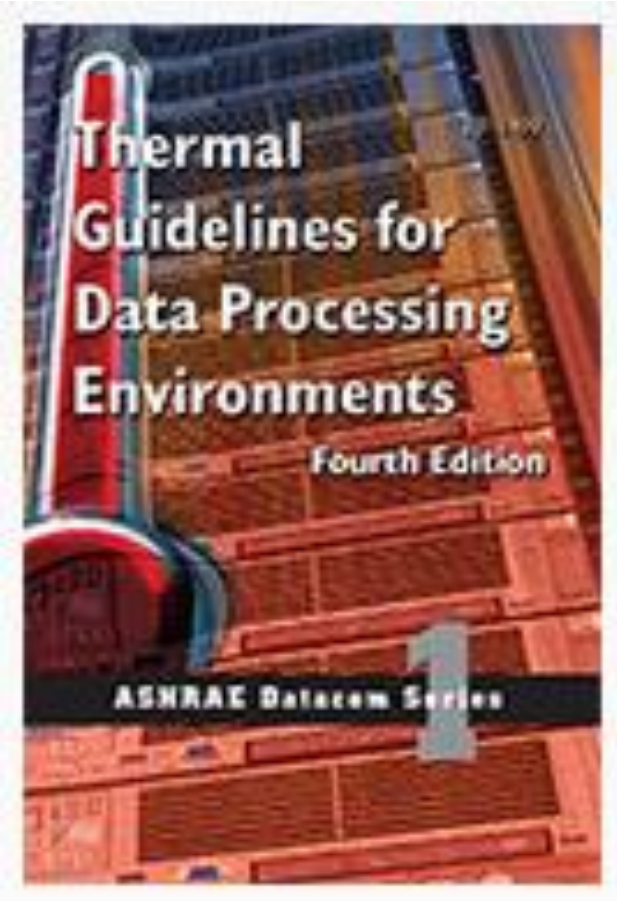
- Five temperature standards defined based on three mechanical system configurations:
  - Chilled water provided by a chiller (with or without a “water side economizer”) at two different temperatures
  - Cooling water provided by a cooling tower with possible chiller backup
  - Cooling water provided by a dry cooler with possible backup using evaporation
  - Building heating water system with dry cooler or cooling tower backup

2014 ASHRAE Liquid Cooling Guidelines

Liquid Cooling Class	Main Cooling Equipment	Supplemental Cooling Equipment	Building Supplied Liquid Cooling Maximum Temperature
W1	Cooling Tower and Chiller	Water Side Economizer	17° C (63° F)
W2	Cooling Tower and Chiller	Water Side Economizer	27° C (81° F)
W3	Cooling Tower	Chiller	32° C (90° F)
W4	Dry Cooler	Spray Dry Cooler, or Chiller	45° C (113° F)
W5	Building Heating System	Cooling Tower or Dry Cooler	> 45° C (>113° F)

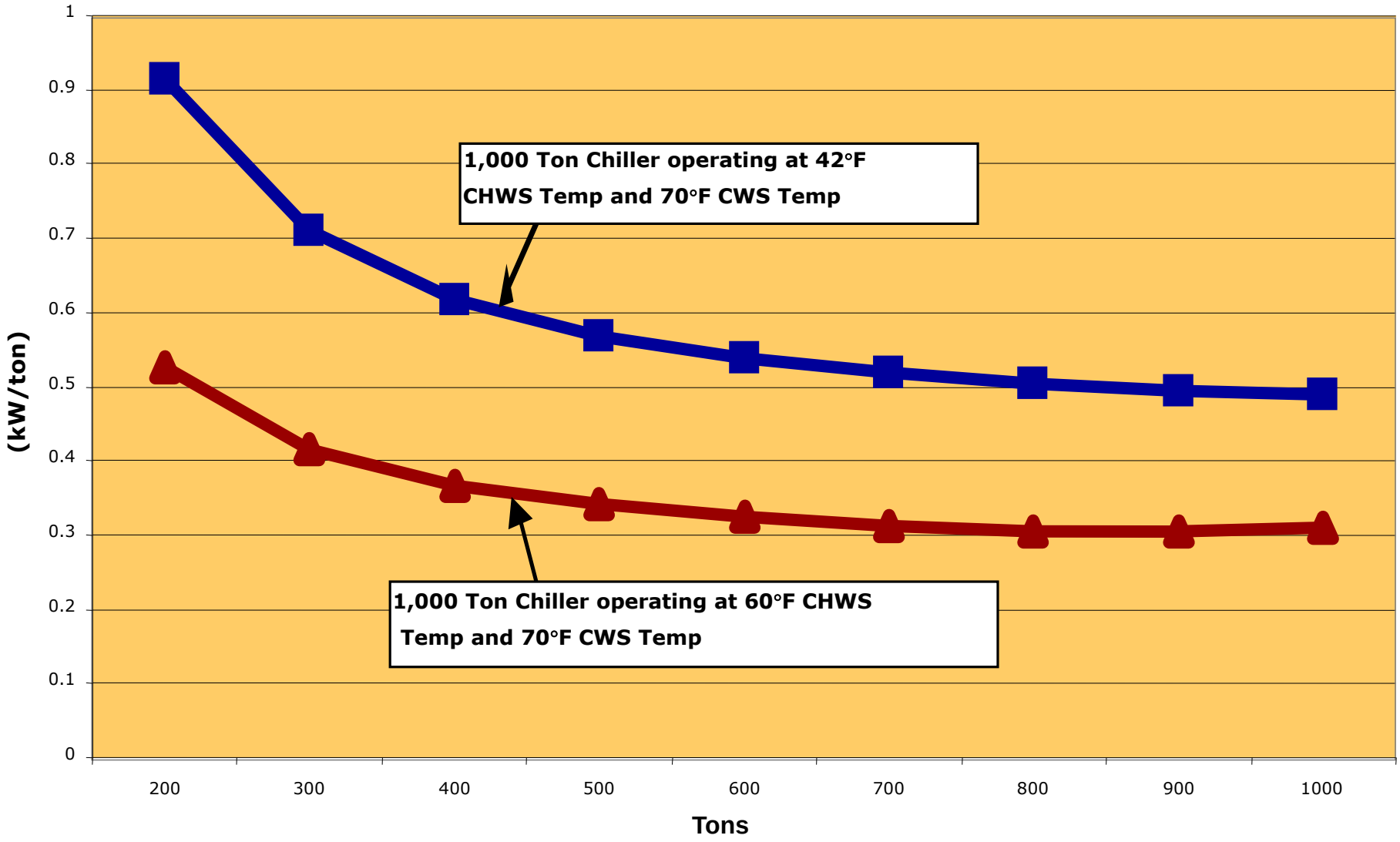
Environmental Conditions Review

- Most computer room air conditioners (CRACs) are controlled based on the return air temperature; *this needs to change*
- A cold data center = efficiency opportunity
- Perceptions, based on old technology, lead to cold data centers with tight humidity ranges; *this needs to change*
- Many IT manufacturers design for harsher conditions than ASHRAE's "default" Class A1
- Design Data Centers for IT equipment performance, *not people comfort*
- **Address air management issues first**



Cooling System Savings from Better Air Management and Revised Environmental Conditions

Increase Temperature of Chilled Water



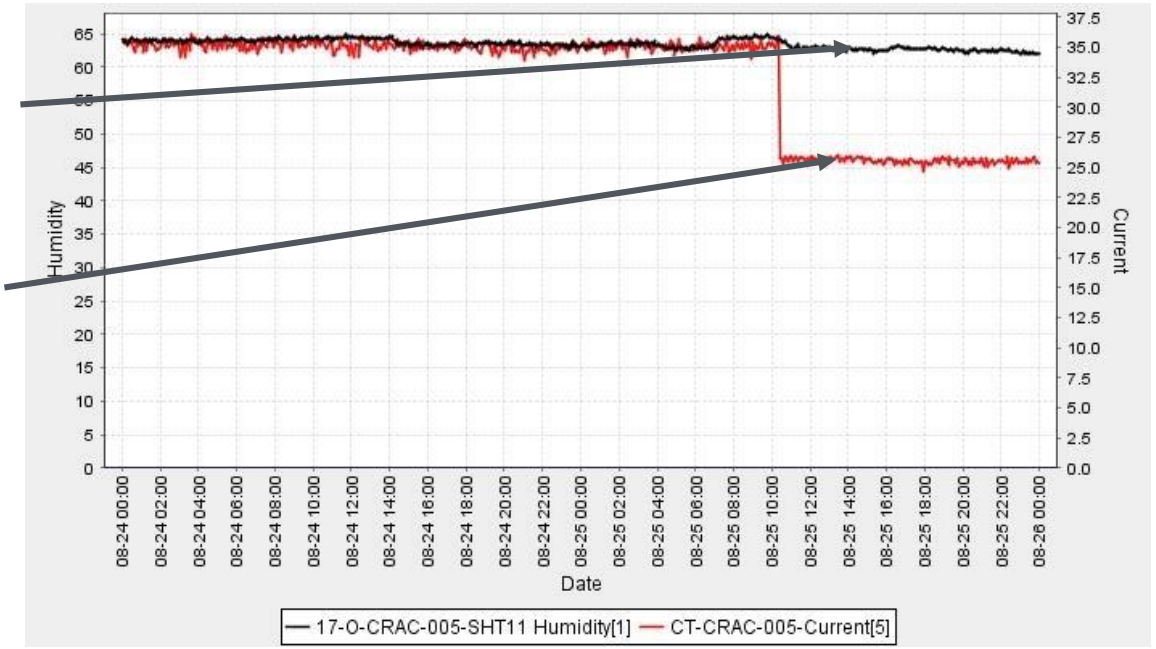
Data provided by York International Corporation

The Cost of Unnecessary Humidification

	Visalia Probe			CRAC Unit Panel			
	Temp	RH	Tdp	Temp	RH	Tdp	Mode
AC005	84.0	27.5	47.0	76	32.0	44.1	Cooling
AC006	81.8	28.5	46.1	55	51.0	37.2	Cooling & Dehumidification
AC007	72.8	38.5	46.1	70	47.0	48.9	Cooling
AC008	80.0	31.5	47.2	74	43.0	50.2	Cooling & Humidification
AC010	77.5	32.8	46.1	68	45.0	45.9	Cooling
AC011	78.9	31.4	46.1	70	43.0	46.6	Cooling & Humidification
Min	72.8	27.5	46.1	55.0	32.0	37.2	
Max	84.0	38.5	47.2	76.0	51.0	50.2	
Avg	79.2	31.7	46.4	68.8	43.5	45.5	

Humidity down 2%

CRAC power down 28%



Use “Free” Cooling

Cooling without Compressors:

- Outside-Air Economizers
- Water-Side Economizers

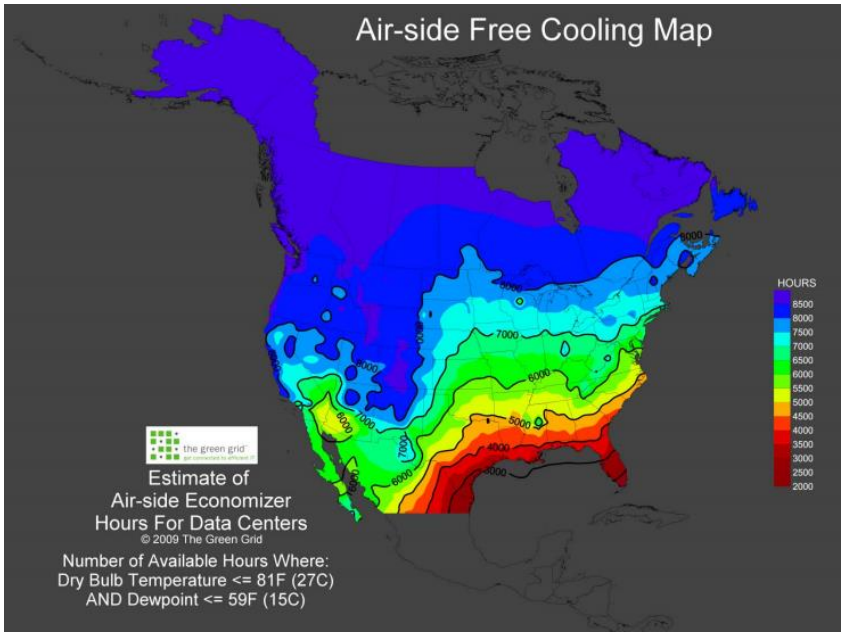
Outside Air (Air-Side) Economizers

Advantages

- Lower energy use
- Added reliability (backup for cooling)

Potential Issues

- Space (retrofit projects difficult)
- Outside dust
  - Not a concern with MERV 13 filters
- Outside gaseous contaminants
  - Not widespread
  - Impacts normally cooled data centers as well
- Shutdown or bypass if smoke or other contaminant is outside data center



http://cooling.thegreengrid.org/namerica/WEB_APP/calc_index.html

Water-Side Economizers

- Easier retrofit
- Added reliability (backup in case of chiller failure)
- No contamination issues
- Put in series with chiller
- Uses tower or dry cooler

No or minimum compressor cooling

Cooling tower and HX = Water-side Economizer

Questions

Contact Information

Steve Greenberg, P.E.
SEGreenberg@lbl.gov
(510) 486-6971

Lawrence Berkeley National Laboratory
MS 90-3111
University of California
Berkeley, CA 94720
https://datacenters.lbl.gov/