Future Proofing Data Centers

E2 HPC Working Group

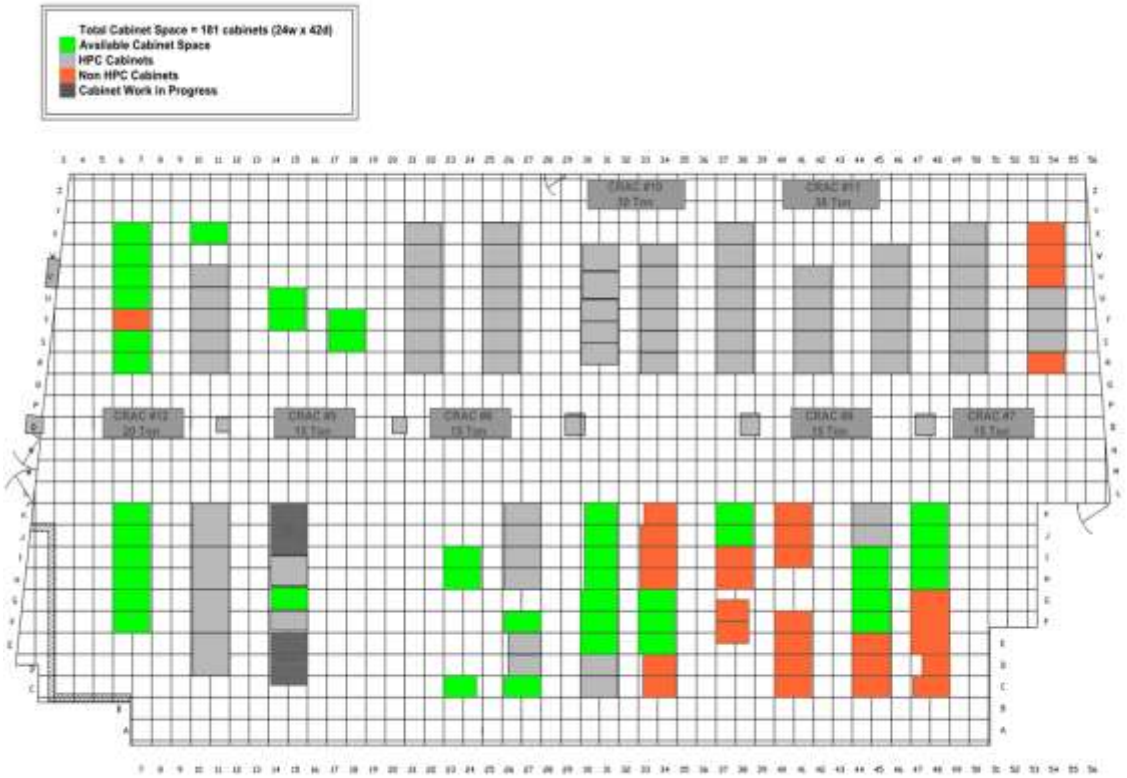
Dale Sartor, Lawrence Berkeley National Laboratory

Future Proofing Our Data Centers

- 10 Year plan for a legacy LBNL data center
- Development of an open liquid cooling standard

10 Year Plan Drivers

- Increase density
- Need for energy efficiency
- Water consumption concern



LBNL Building 50B Room 1275 Data Center

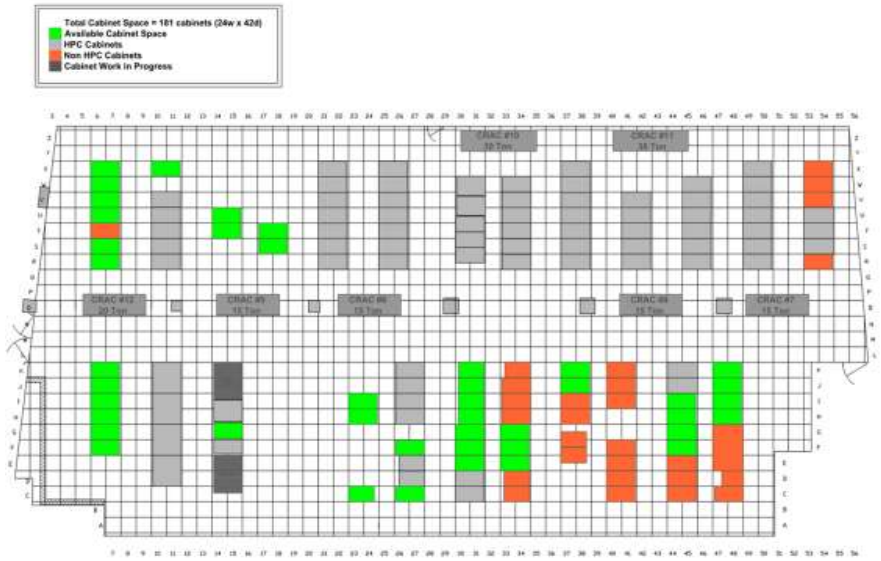
Existing Conditions & Targets

- IT MW: 0.5 growing to 1.2
- Space: Same or less
- PUE: 1.65 reduce to 1.2 (1.1 stretch)

➢ Conceptual 10 year plan developed by Point Energy Innovations

Non-homogeneous IT Configuration

- Legacy and inherited systems
- New(er) air cooled equipment
  - Small supercomputers and multi-rack clusters
- Future high density racks
  - 30kW



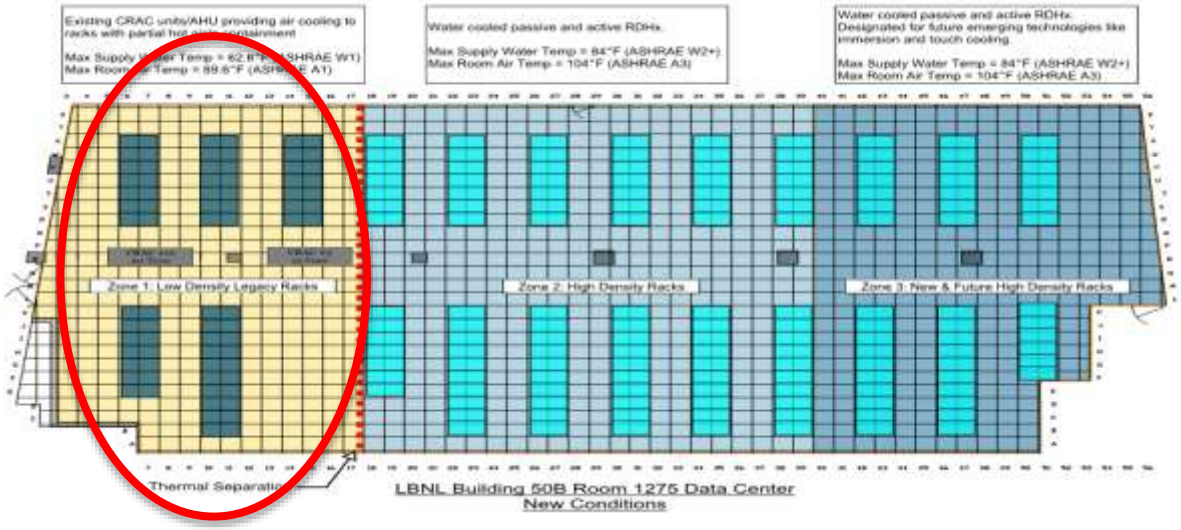
LBNL Building 50B Room 1275 Data Center

3 Zone Design Solution

Zone 1. Legacy:

- ASHRAE A1: 80.6 deg F operating, 89.6 deg F maximum

2. High density air cooled IT:
   - ASHRAE A3: 80.6 deg F operating, 104 deg F max
3. High density direct liquid cooled
   - ASHRAE W3+ warm water cooling
   - Airspace cooled as zone 2

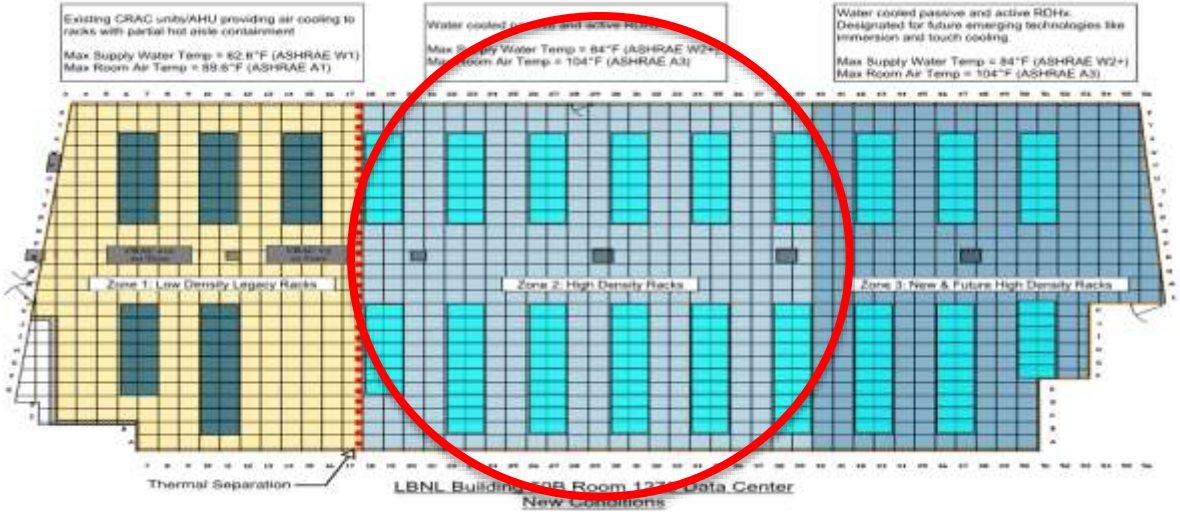


3 Zone Design Solution

1. Legacy:
   - ASHRAE A1: 80.6 deg F operating, 89.6 deg F max

Zone 2. High density air cooled IT:
   - ASHRAE A3: 80.6 deg F operating, 104 deg F maximum

3. High density direct liquid cooled
   - ASHRAE W3+ warm water cooling
   - Airspace cooled as zone 2



3 Zone Design Solution

1. Legacy:
   - ASHRAE A1: 80.6 deg F operating, 89.6 deg F max
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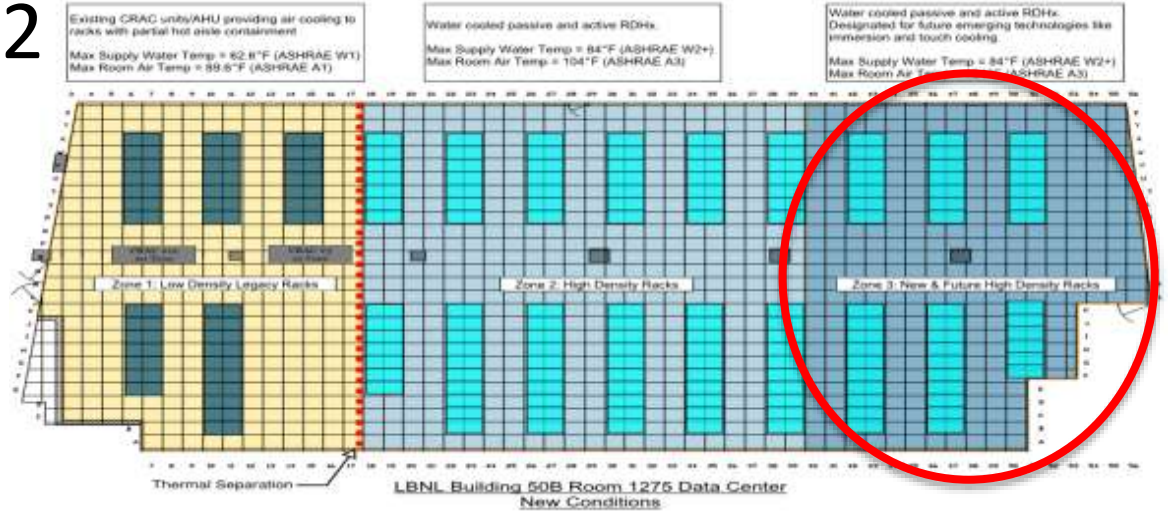
Zone 3. High density direct liquid cooled

- ASHRAE W3+ warm water cooling
- Airspace temperature = zone 2



ASHRAE Design Reference Conditions - 2015

Air side Conditions

Legacy equipment

New racks with rear door ht exchangers

Class	2015 ASHRAE Equipment Environmental Specifications for Air Cooling						
	Product Operations					Product Power Off	
	Dry-Bulb Temperature °F	Humidity Range, Non-Condensing	Maximum Dew Point °F	Maximum Elevation ft	Maximum Temperature Range [15 min/1 hr] °F	Dry-Bulb Temperature °F	Relative Humidity %
Recommended (Suitable for all 4 classes)							
A1 to A4	64.4 to 80.6	15.8°F DP to 59°F DP and 60%RH					
Allowable							
A1	59 to 89.6	10.4°F DP & 8% RH to 62.6°F and 80% RH	62.6	10,006	9/36	41 to 113	8 to 80
A2	50 to 95	10.4°F DP & 8% RH to 69.8°F and 80% RH	69.8	10,006	9/36	41 to 113	8 to 80
A3	41 to 104	10.4°F DP & 8% RH to 75.2°F and 85% RH	75.2	10,006	9/36	41 to 113	8 to 80
A4	41 to 113	10.4°F DP & 8% RH to 75.2°F and 90% RH	75.2	10,006	9/36	41 to 113	8 to 80
B	41 to 95	8% to 82.4°F DP and 80% RH	82.4	10,006	9/36	41 to 113	8 to 80
C	41 to 104	8% to 82.4°F DP and 80% RH	82.4	10,006	9/36	41 to 113	8 to 80

Water side Conditions

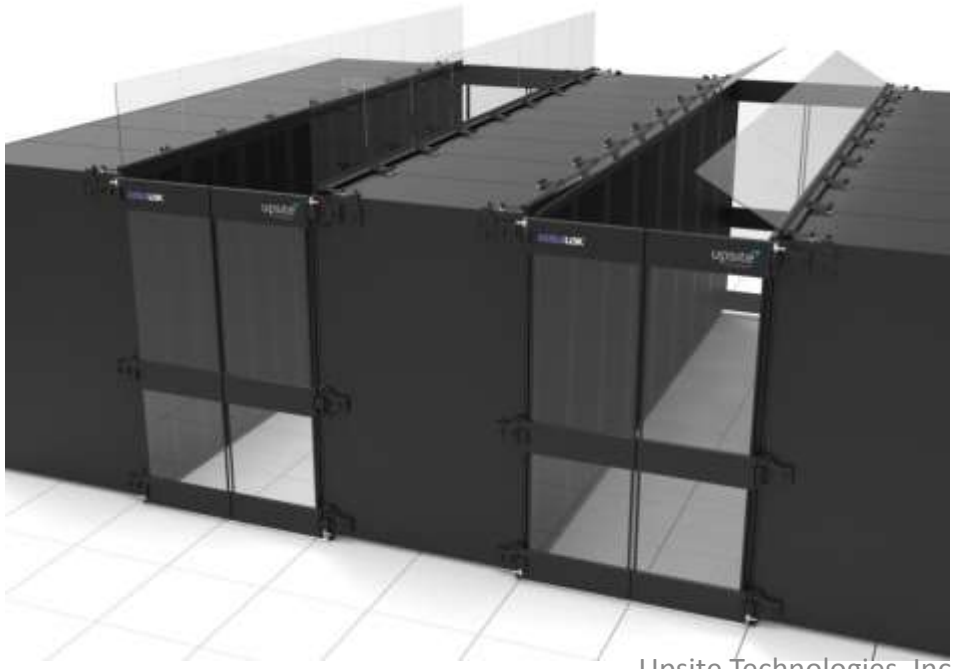
New Racks
(W2 Condition - with the exception of delivering 84 deg F water on peak WB days)

Liquid Cooling Classes	Typical Infrastructure Design		Facility Supply Water Temperature
	Main Heat Rejection Equipment	Supplemental Cooling Equipment	
W1	Chiller/Cooling Tower	Water-side Economizer (With Drycooler or Cooling Tower)	35.6°F to 62.6°F
W2			35.6°F to 80.6°F
W3	Cooling Tower	Chiller	35.6°F to 89.6°F
W4	Water-side Economizer (With Drycooler or Cooling Tower)	N/A	35.6°F to 113°F
W5	Building Heating System	Cooling Tower	>113°F

Zone 1 Heat Collection Solution

Legacy (ASHRAE A1: 80.6 degF operating, 89.6 deg F max):

- Air cooled
- Raised floor
- Partial hot aisle containment
- Existing AHU and CRAC units



Upsite Technologies, Inc

Zone 2 Heat Collection Solution

High density (ASHRAE A3: 80.6 deg F operating, 104 deg F max):

- Passive and active rear door heat exchangers
  - Selection based on rack load
- Rear doors supplied with 66 deg F operating, 84 deg F max water temp

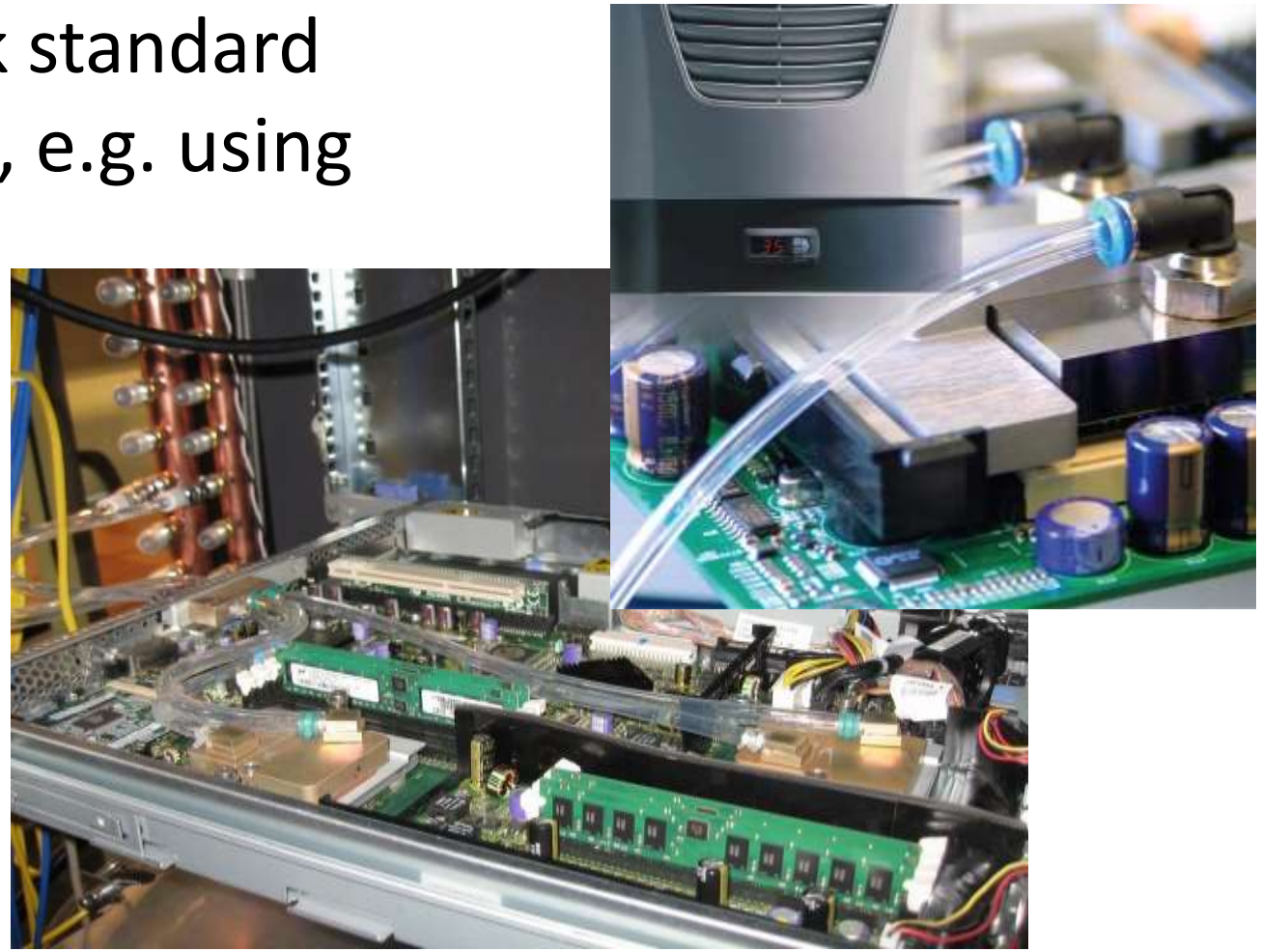
Passive Rear Door Heat Exchanger

Rear Door Heat Exchanger w/ Fan Assist

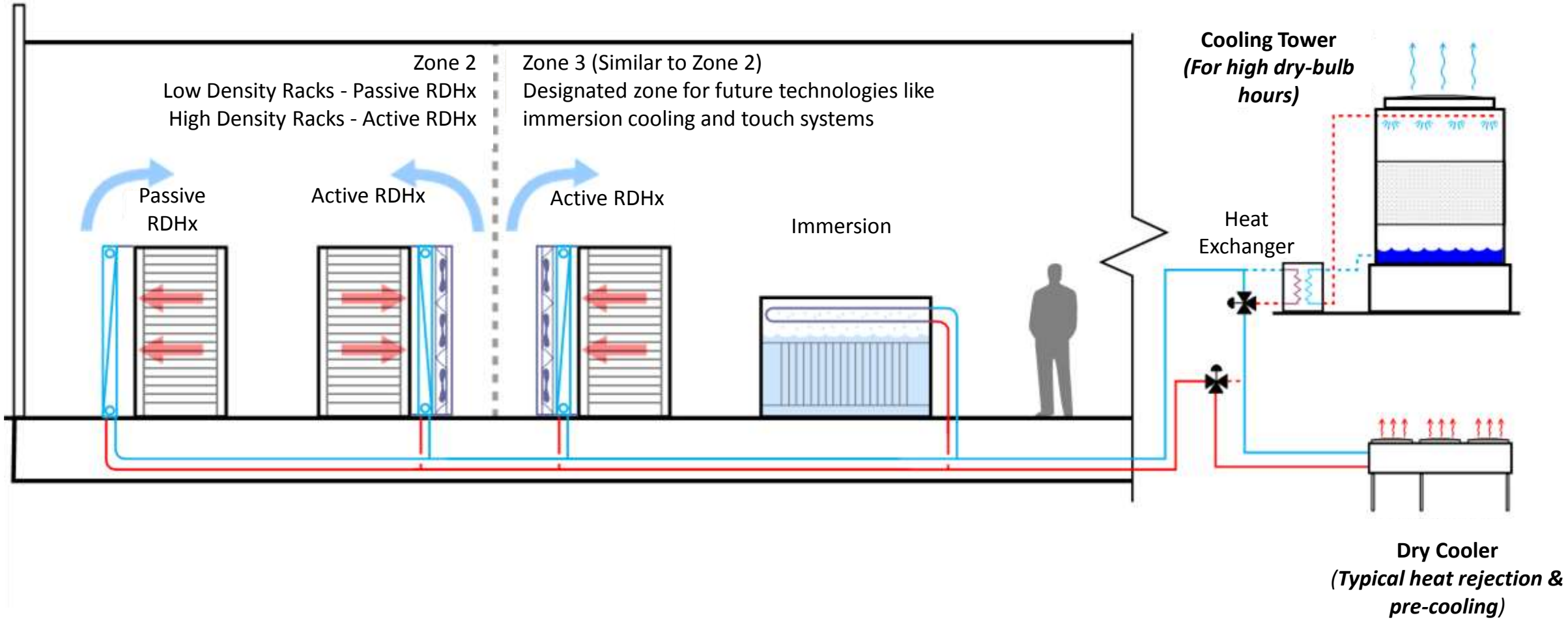
Zone 3 Heat Collection Solution

Super high density direct liquid cooled:

- Need for liquid cooling rack standard
- Warmer water can be used, e.g. using effluent from Zone 2

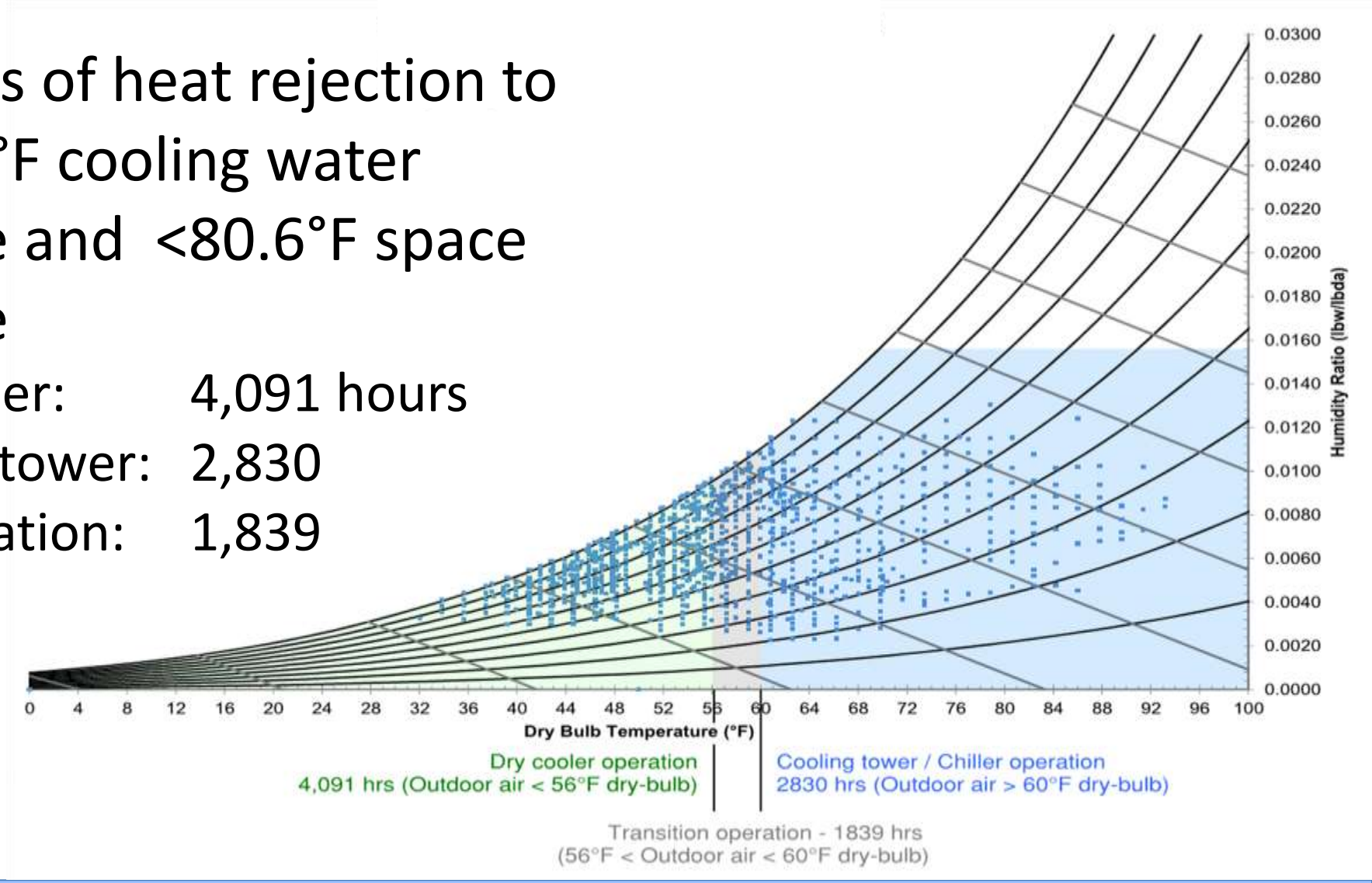


System Diagram

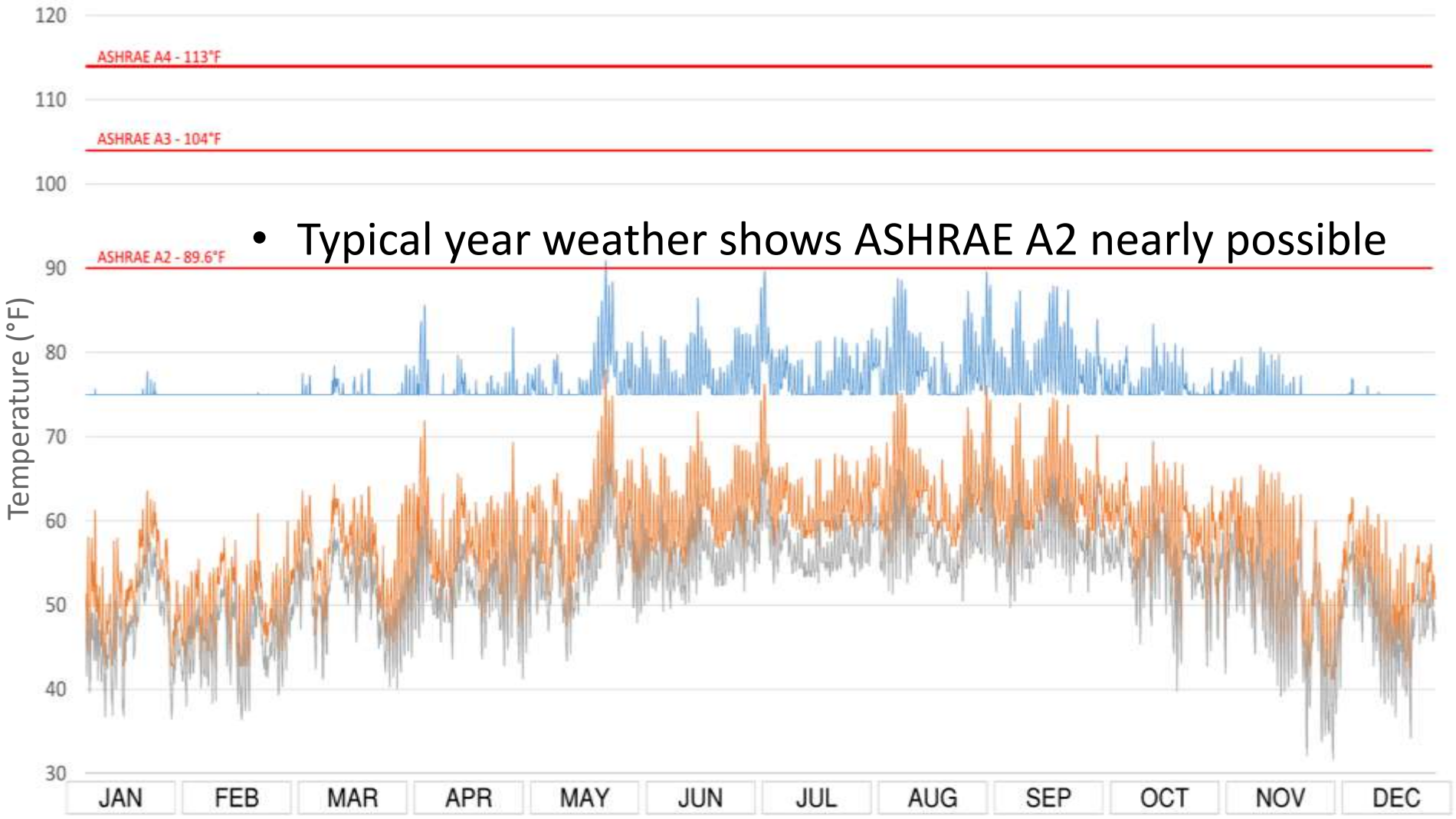


Design Conditions

- Annual hours of heat rejection to maintain 66°F cooling water temperature and <80.6°F space temperature
  - Dry cooler: 4,091 hours
  - Cooling tower: 2,830
  - Combination: 1,839



Performance Analysis



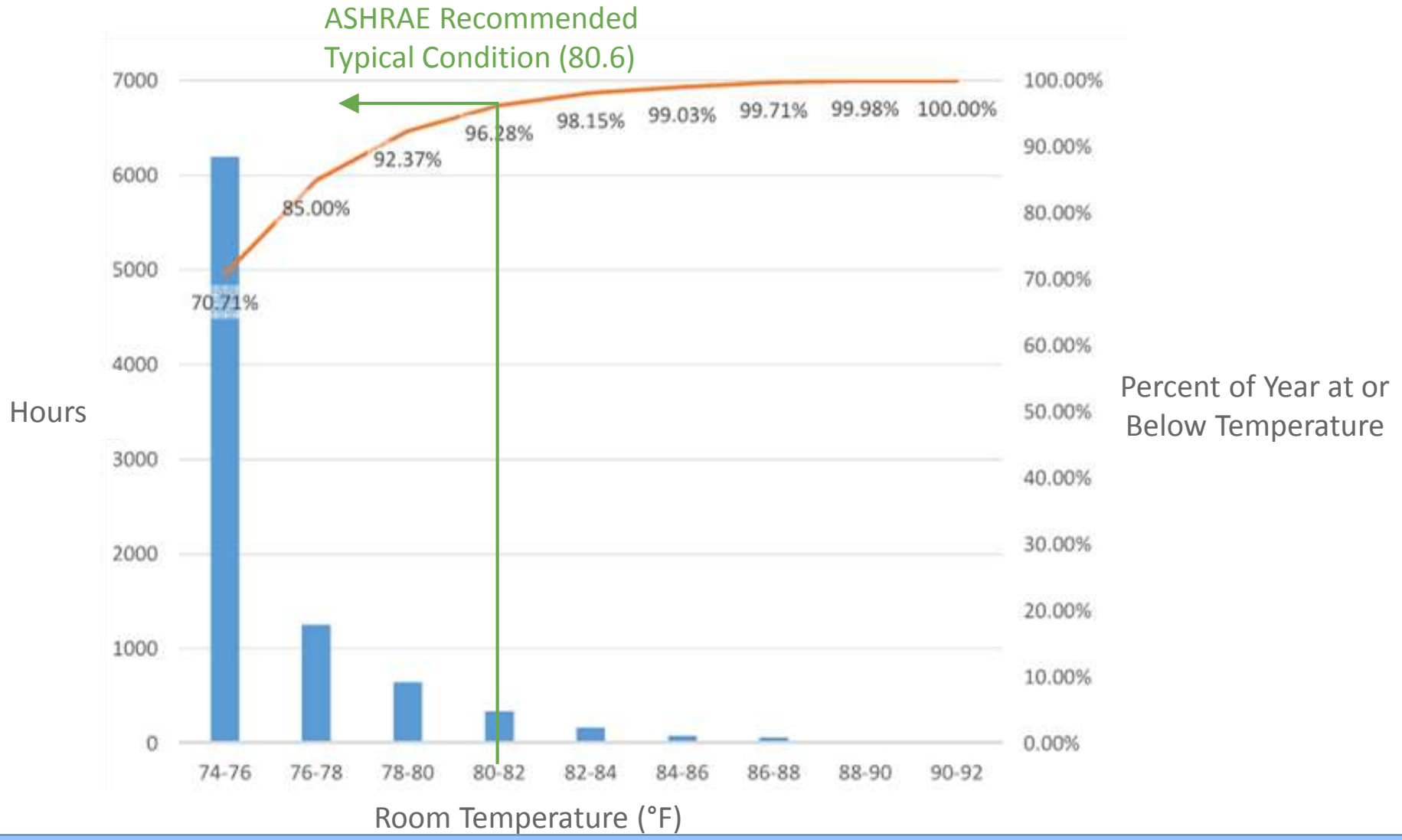
- Typical year weather shows ASHRAE A2 nearly possible

Room Temp

Treated Water Temp

Outdoor Air Wetbulb Temp

Room Air Temperature Analysis

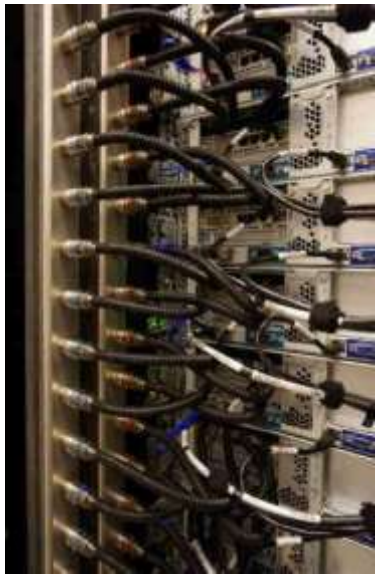


Benefits of Liquid Cooling

- Higher compute densities
- Higher efficiency
  - Heat removal
  - Transport energy
  - cooling plant
  - Increased economizer hours
  - Potential use of waste heat

Liquid Cooled Rack Standard

- While liquid cooling potential is understood, uptake is slow
- Most solutions are unique and proprietary
- Needed:
  - Multi-source solution
  - Reusable rack infrastructure
- Users can drive faster technology development and adoption



International Open Data Center Specifications

- Target Organizations:
  - The Open Compute Project (OCP) – US
  - Scorpio Project – China
- Collaborators:
  - Facebook
  - Google
  - Intel
  - Baidu
  - Alibaba
  - Tencent

Key Liquid Cooled Rack Specifications

- Key Specifications (lunch discussion):
  - Fluid selection and quality
  - Supply pressure, temperature, and flow
  - Delta pressure and temperature
  - Header size and material, connection spacing, size, and details
- Goal:
  - A liquid cooled rack specification that could accommodate multiple vendors and provide an infrastructure for multiple refresh cycles with a variety of liquid cooled servers/suppliers.

Thank you!

Please save your questions for the end of the session.

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