ASHRAE Thermal Guidelines

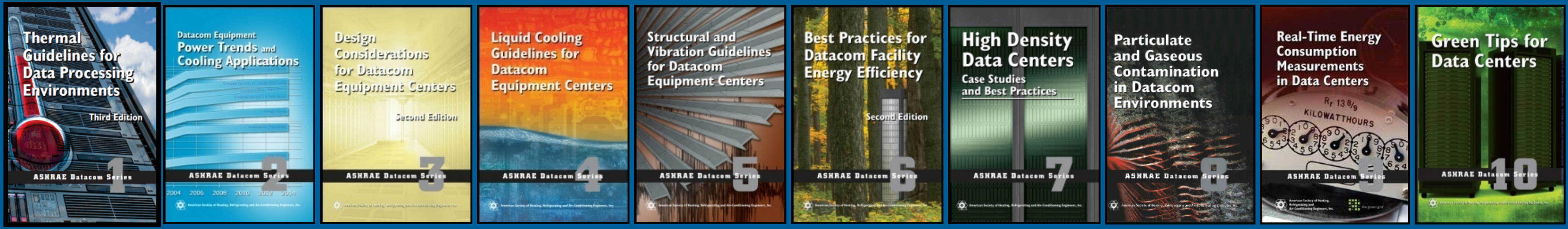
Agenda

- ASHRAE and TC9.9
- Thermal Guidelines (Third Edition)
  - Air-cooling
  - Liquid-cooling
- Air-cooling thermal guidelines in practice
  - Performance
  - Reliability

ASHRAE and TC 9.9

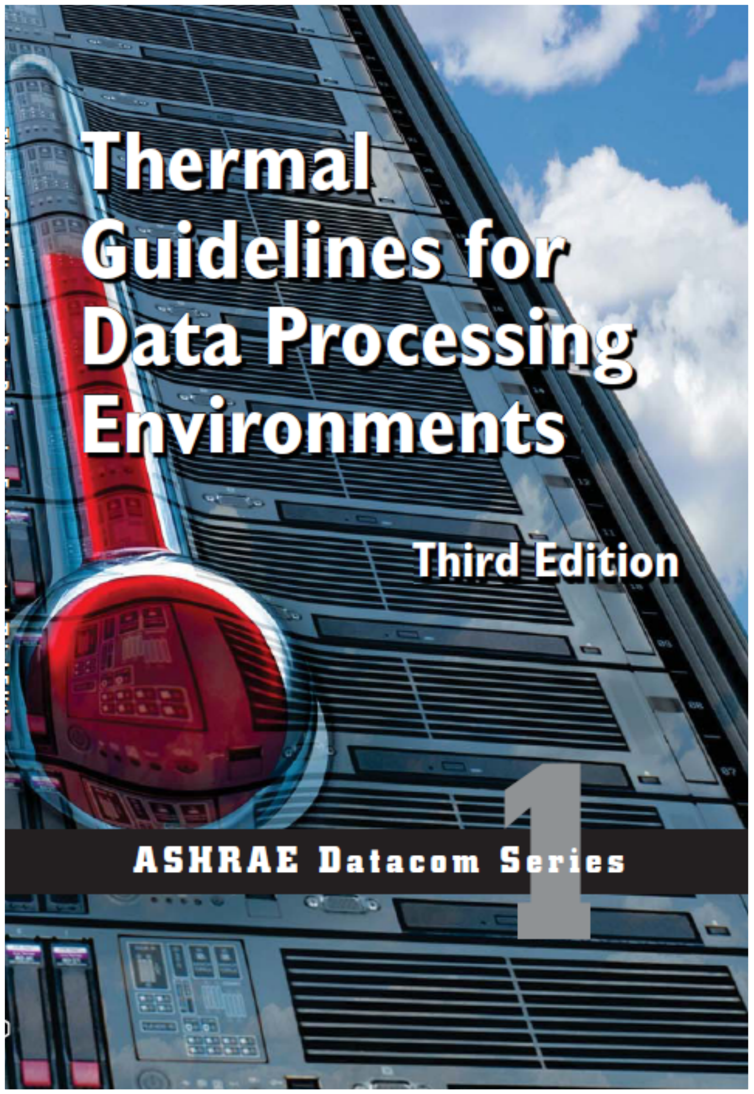
- **ASHRAE**
  - American Society of Heating, Refrigeration and Air-Conditioning Engineers
- **Technical Committee 9.9**
  - Technical Committee 9.9 – Mission Critical Facilities, Data Centers, Technology Spaces, & Electronic Equipment (http://tc99.ashraetcs.org/index.html)
  - Environment – thermal, structural, design, testing of data centers and technology spaces for IT equipment
- **Committee Members**
  - IT equipment manufacturers
  - Environmental equipment manufacturers
  - Data center designers
  - End users

TC 9.9 Datacom Book Series



1. **Thermal Guidelines for Data Processing Environments 3rd Edition**
2. Datacom Equipment Power Trends & Cooling Applications 2nd Edition (2012)
3. Design Considerations for Datacom Equipment Centers (2006)
4. Liquid Cooling Guidelines for Datacom Equipment Centers 2nd Edition (2014)
5. Structural & Vibration Guidelines for Datacom Equipment Centers (2008)
6. Best Practices for Datacom Facility Energy Efficiency (2008)
7. High Density Data Centers – Case Studies & Best Practices (2008)
8. Particulate & Gaseous Contamination in Datacom Environments (2009)
9. Real-Time Energy Consumption Measurements in Data Centers (2009)
10. Green Tips for Data Centers (2011)

Thermal Guidelines for Data Processing Environments



Chapter 1 – Introduction

Chapter 2 – Environmental Guidelines for Air-Cooled Equipment

Chapter 3 – Environmental Guidelines for Liquid-Cooled Equipment

Chapter 4 – Facility Temperature & Humidity Measurement

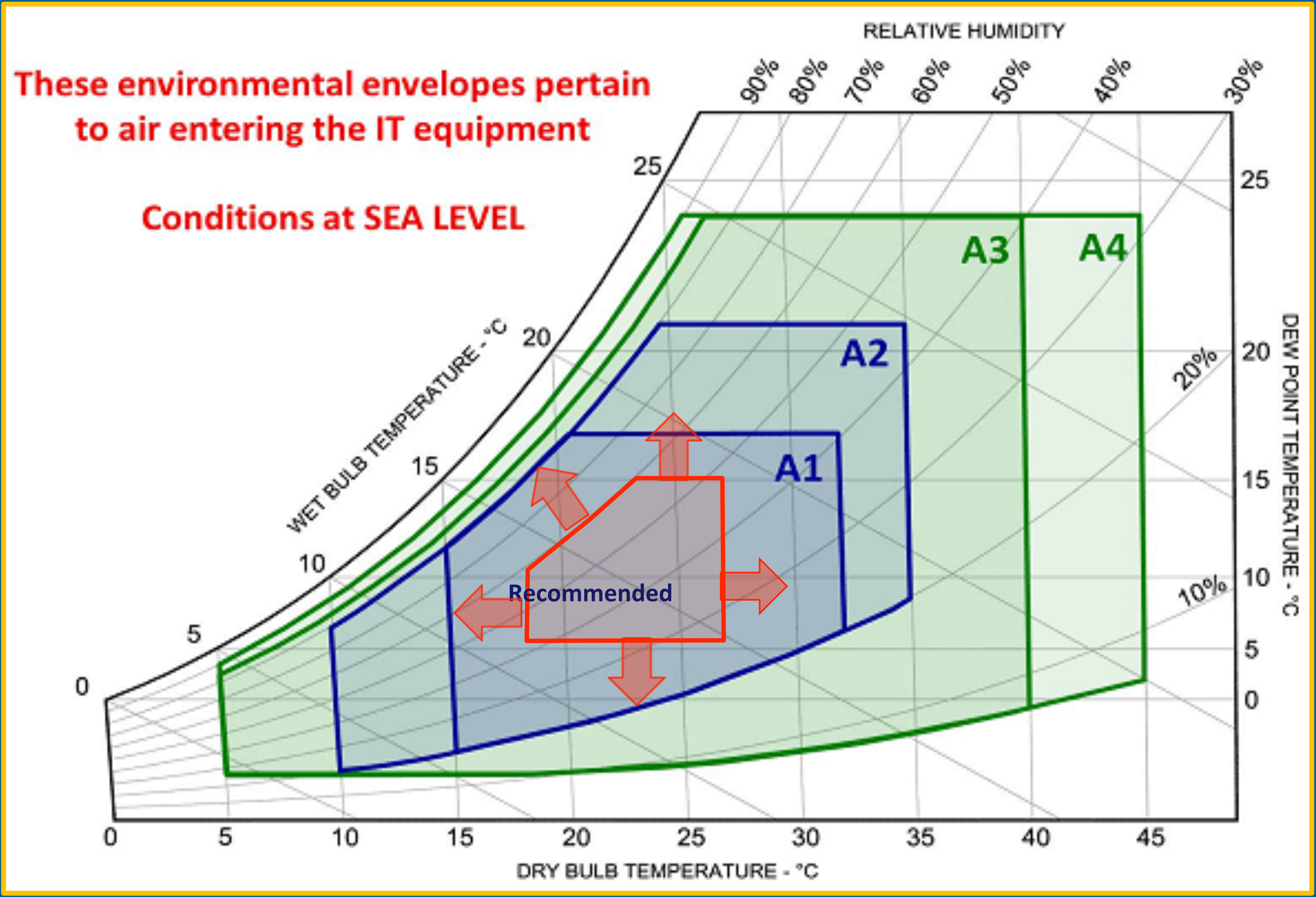
Chapter 5 – Equipment Placement & Airflow Patterns

Chapter 6 – Equipment Manufacturers Heat & Airflow Reporting

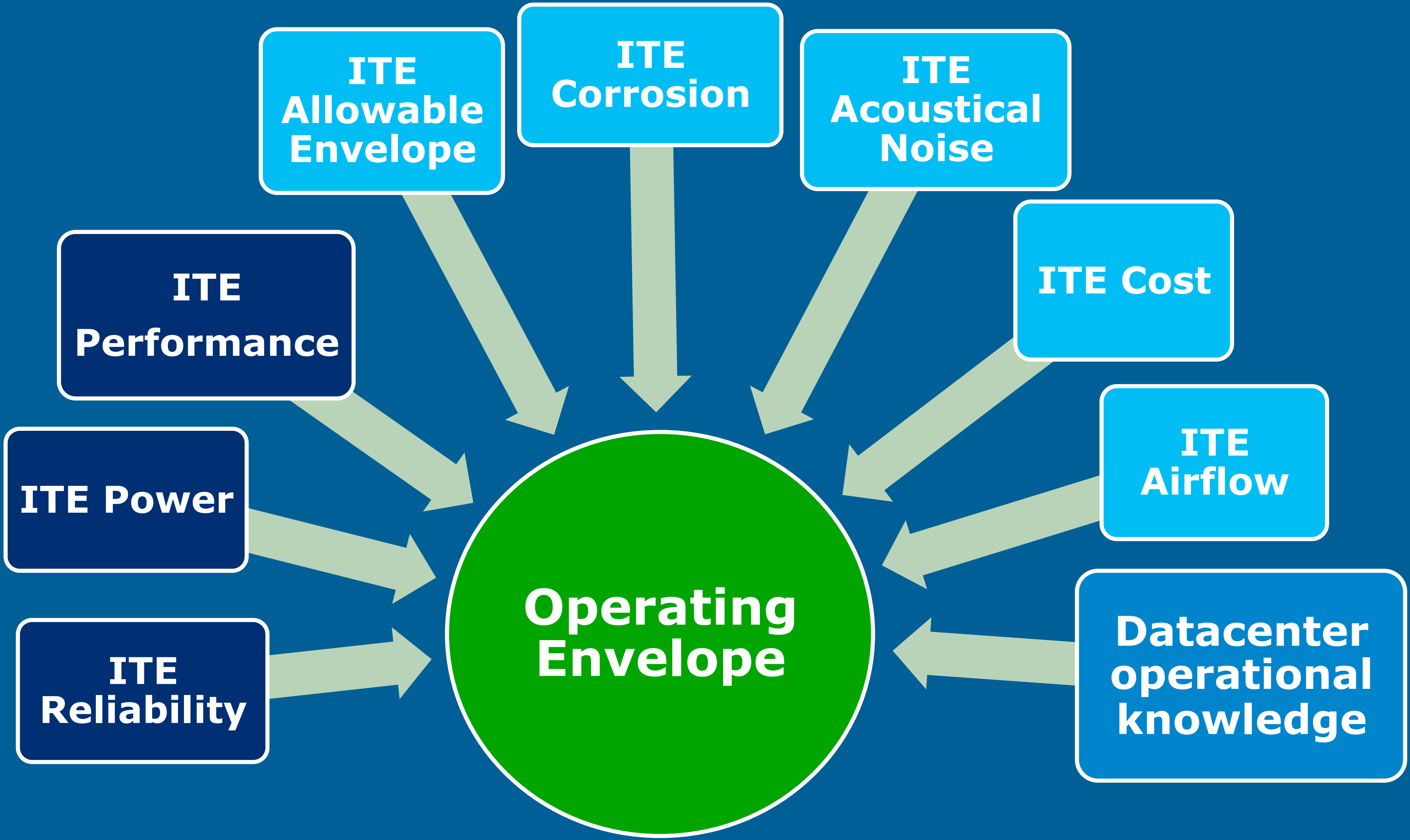
Air-Cooled IT Equipment Class Ranges

- **Allowable Range** – ITE designed to function within this range
- **Recommended Range** – Guidance from ITE manufacturers for high reliability, minimal power consumption (of ITE) and maximum performance
- **Operating Range** – Actual limits for an individual datacenter
    - Can begin with the recommended range
    - Dependent upon datacenter operator's evaluation of ITE factors described in the whitepaper in combination with knowledge of the datacenter design

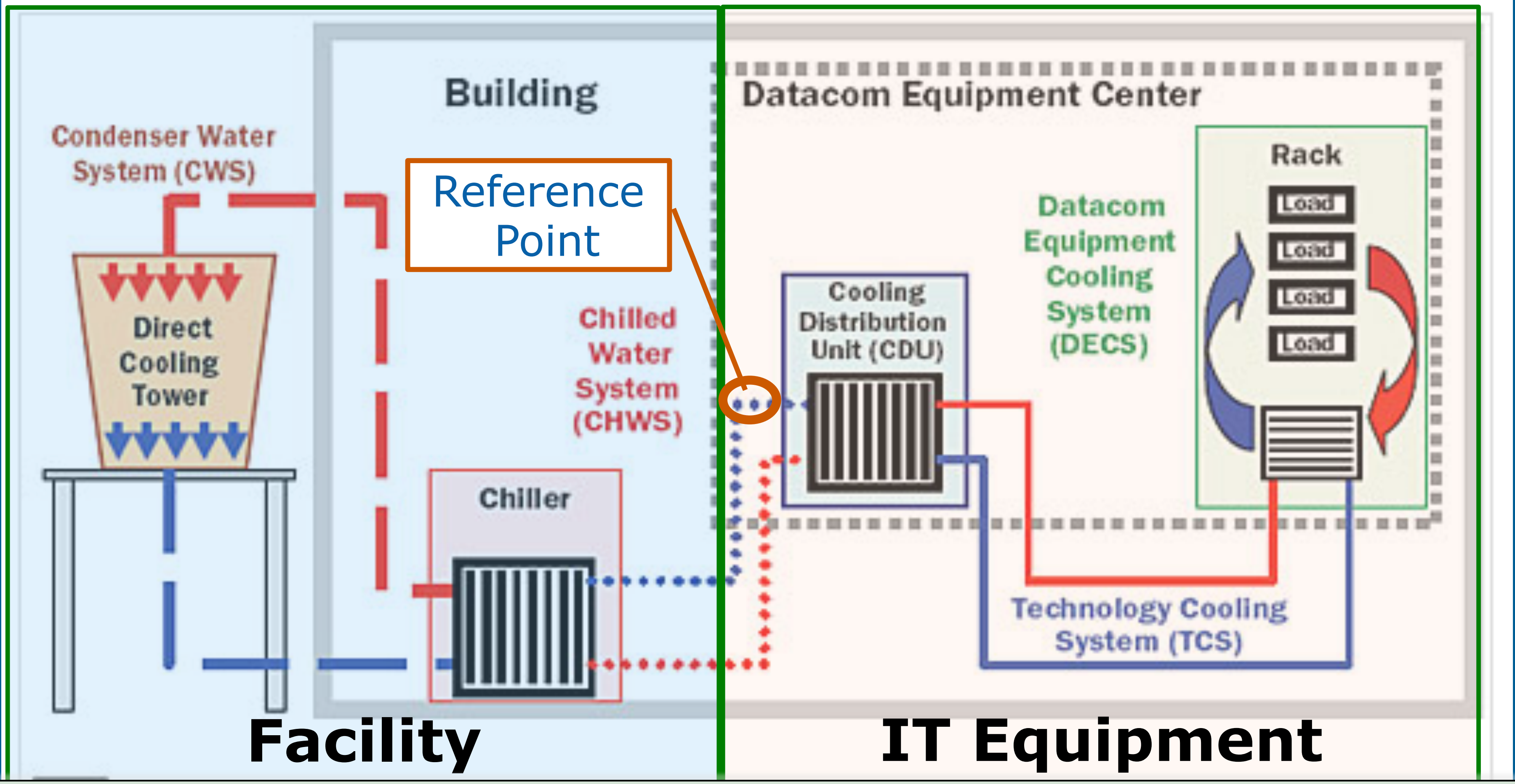
2011 ASHRAE Thermal Guidelines



Operating Envelope



Liquid-Cooling Environments

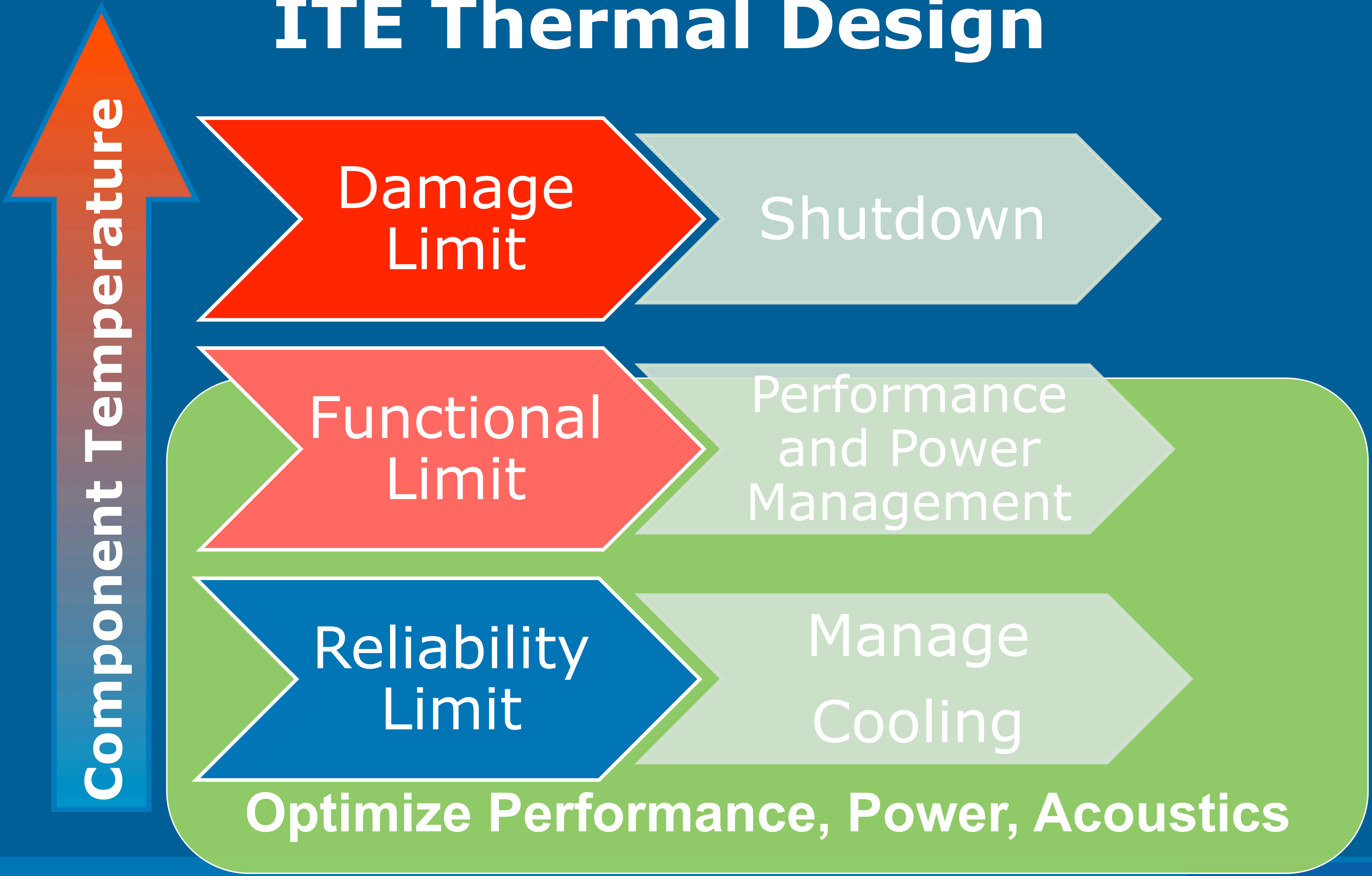


Atmosphere ← Building ← Room ← Aisle ← Rack ← System ← Board ← Chip

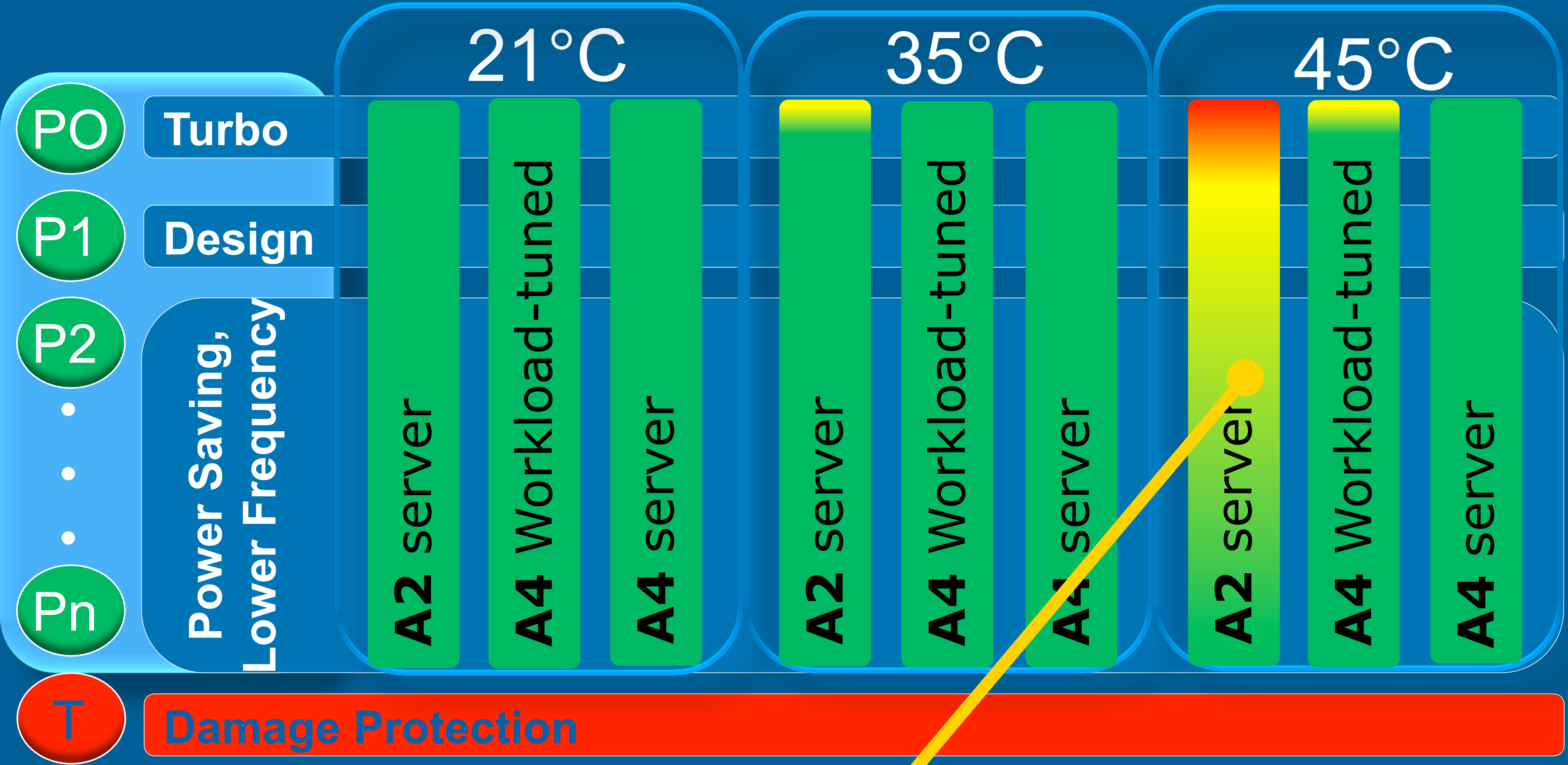
2011 ASHRAE Liquid-Cooled Guidelines

Classes	Main Cooling Equipment	Supplemental Cooling Equipment	Facility Supply Water Temp (°C)
W1	Chiller/Cooling Tower	Water-side Economizer (w/ drycooler or cooling tower)	2 – 17
W2			2 – 27
W3	Cooling Tower	Chiller	2 – 32
W4	Water-side Economizer (w/ drycooler or cooling tower)	N/A	2 – 45
W5	Building heating system	Cooling tower	> 45

ITE Thermal Design

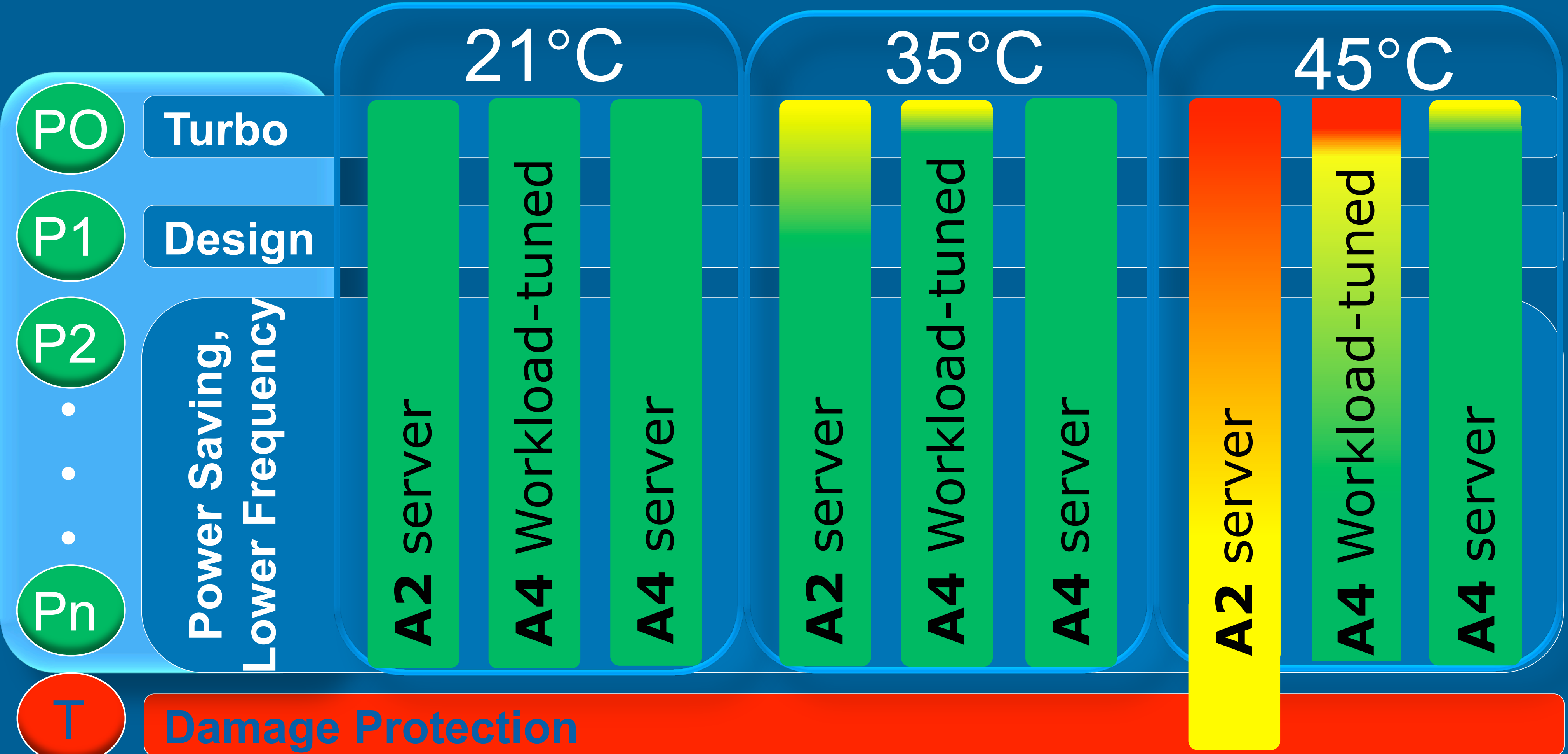


CPU Performance – Light Load



Unpredictable performance, memory follows a similar trend although throttling mechanism is different

CPU Performance – Heavy Load



Performance – dependent on adequacy of thermal design

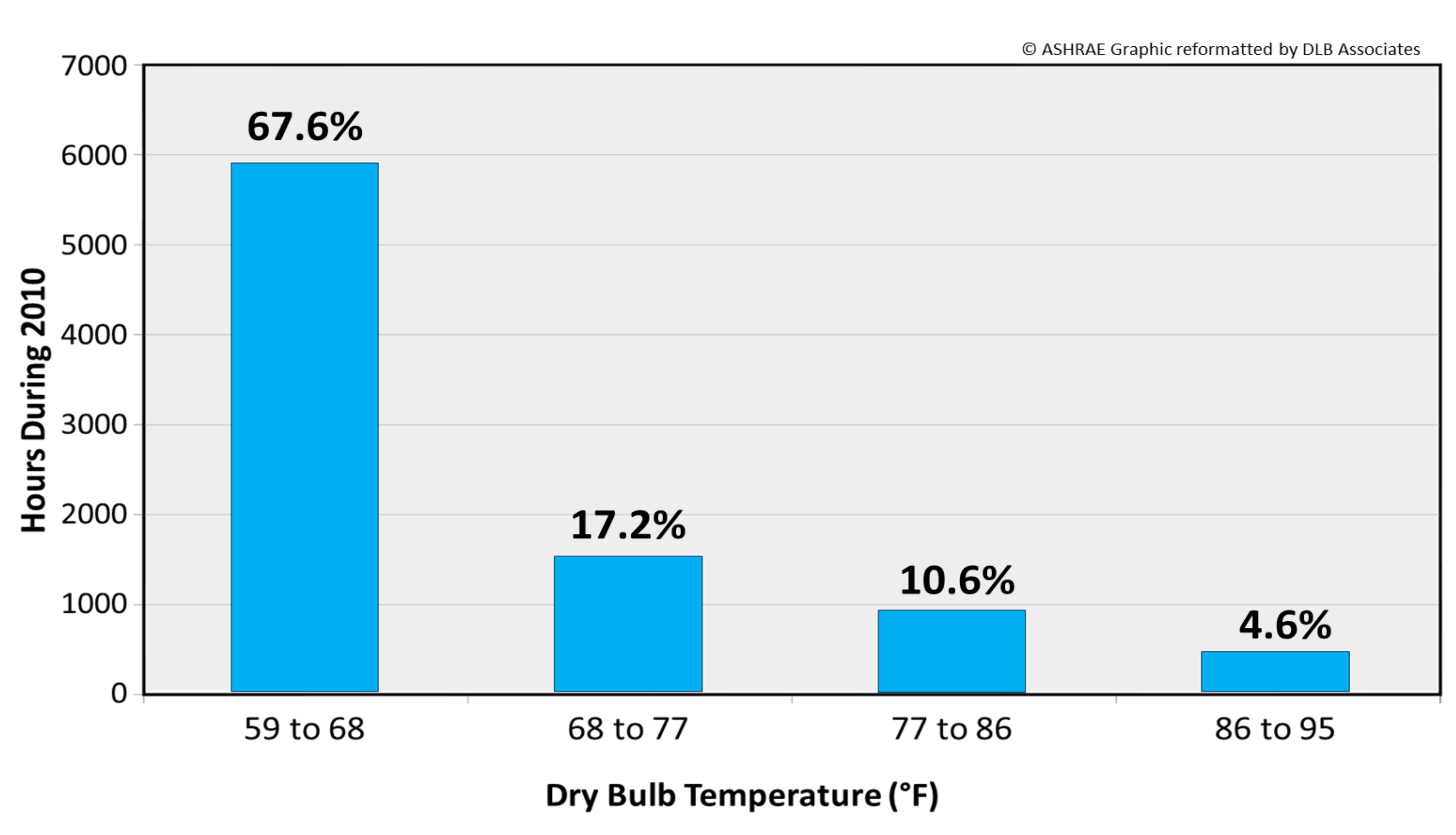
Reliability 'X-Factor'

Server Reliability Trend vs. Ambient Temperature – Relative Failure Rates			
Dry Bulb Temp. (°F)	**Hardware Failure Rate for Volume Servers (X-Factor)**		
	Average	Lower Bound	Upper Bound
59	0.72	0.72	0.72
63.5	0.87	0.80	0.95
68	1.00 (Baseline)	0.88	1.14
72.5	1.13	0.96	1.31
77	1.24	1.04	1.43
81.5	1.34	1.12	1.54
86	1.42	1.19	1.63
95	1.55	1.35	1.74
104	1.66	1.51	1.81
113	1.76	1.67	1.84

Assumes continuous (7 x 24 x 365) operation with Dry Bulb Temp. at ITE inlet.

Server Reliability Trend vs. Ambient Temperature (cont.)

- 2010 dry bulb temp for Chicago with air mixing to maintain 59°F min. temp.



Application of X-Factor (Chicago example)

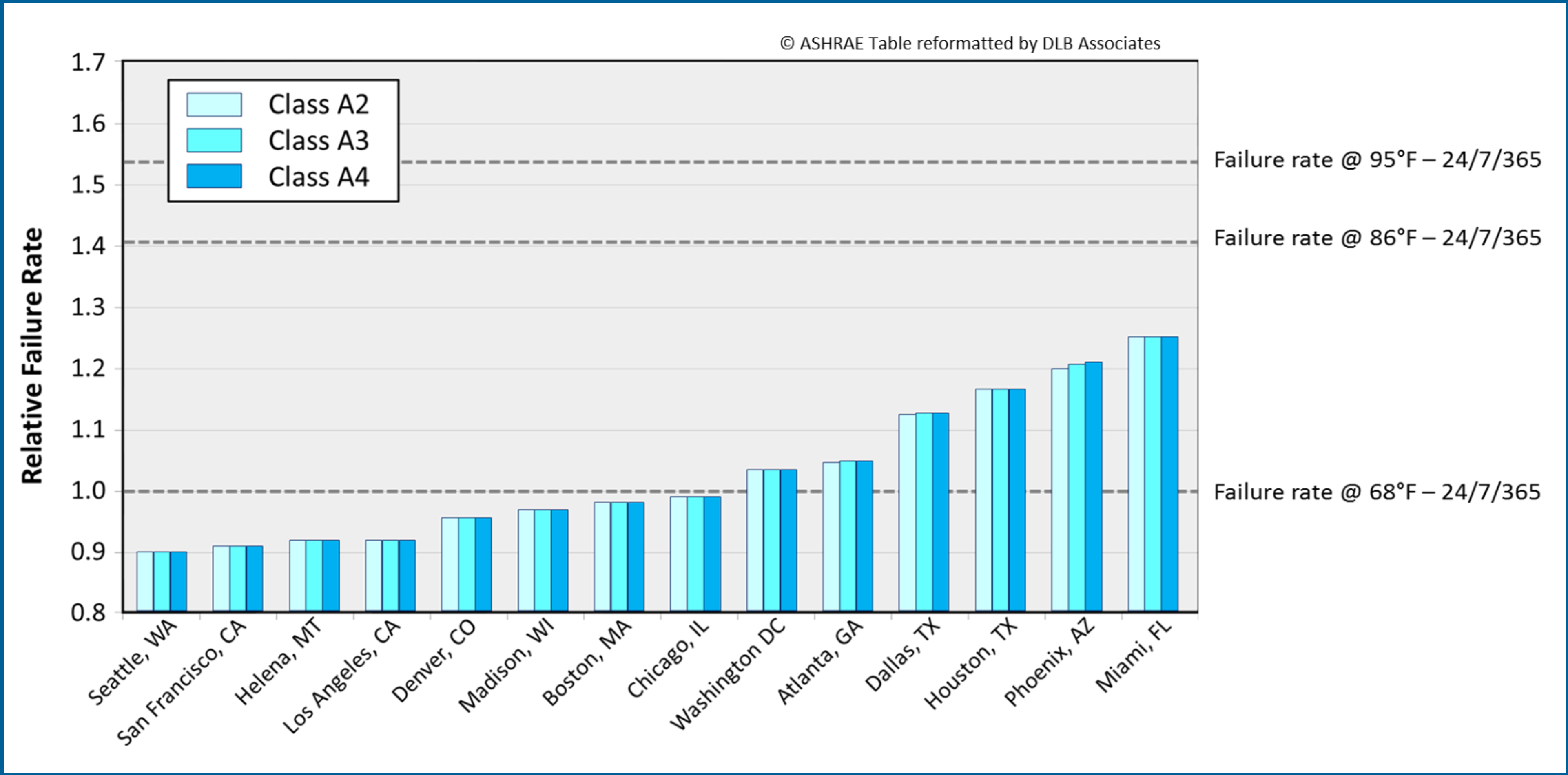
- Cross referencing the hardware failure rates with the dry bulb data for Chicago, we can establish the Net X-Factor across the whole year.

Time-at-Temperature Weighted Failure Rate Calculation for IT Hardware									
Location	59-68°F		68-77°F		77-86°F		86-95°F		Net X-Factor
	% hours	Avg. X-Factor	% hours	Avg. X-Factor	% hours	Avg. X-Factor	% hours	Avg. X-Factor	
Chicago	67.6	**0.865**	17.2	**1.13**	10.6	**1.335**	4.6	**1.482**	**0.99**

The Net X-Factor for in Chicago IT hardware failure with compressor-less cooling and a variable data center temperature is almost exactly the SAME as if the data center was operating at a tightly controlled temp. of 68°F.

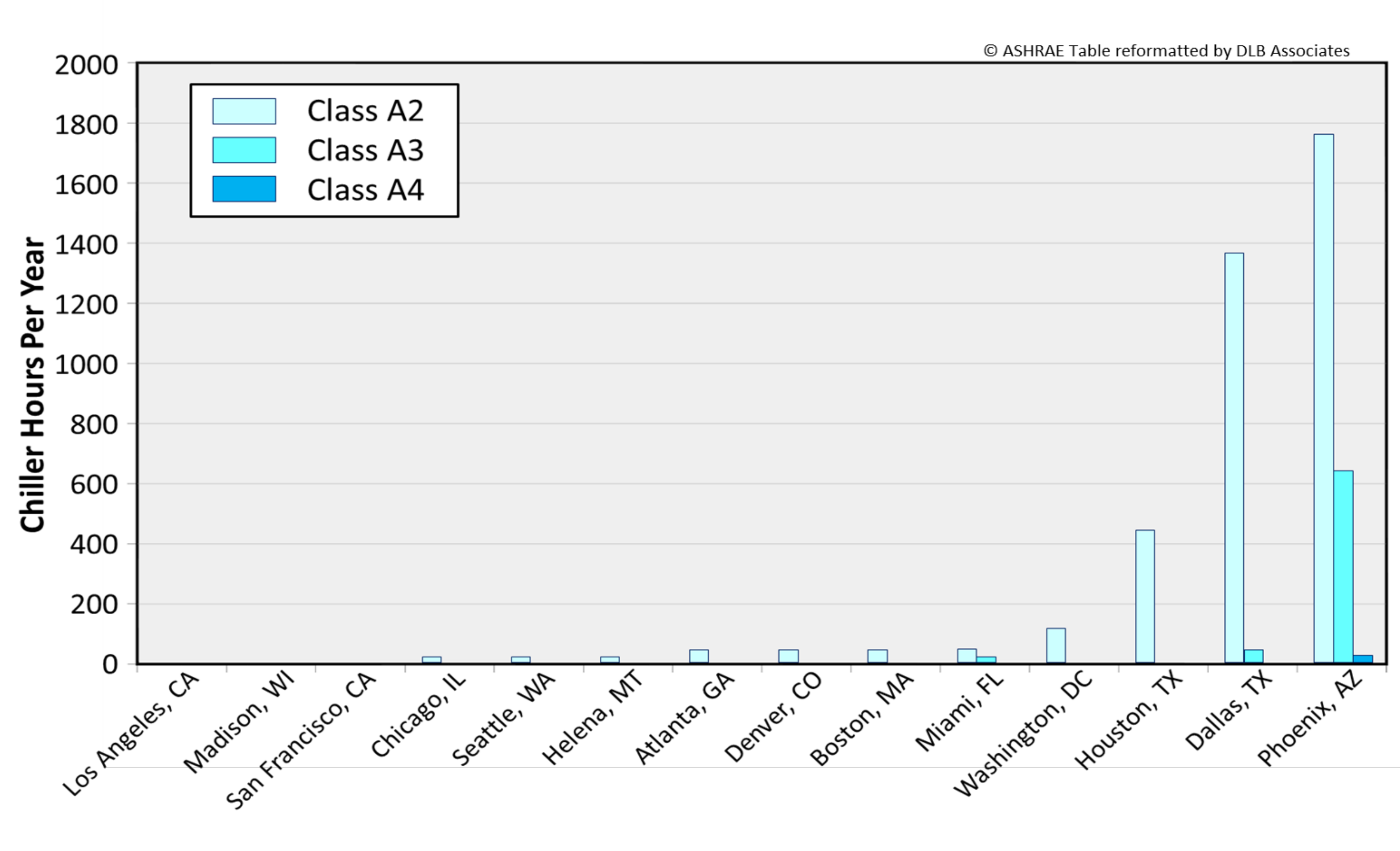
City Comparison: Reliability

- Average Net Failure Rate Comparison for Air-side Economization (US Cities)



City Comparison: Chiller Hours

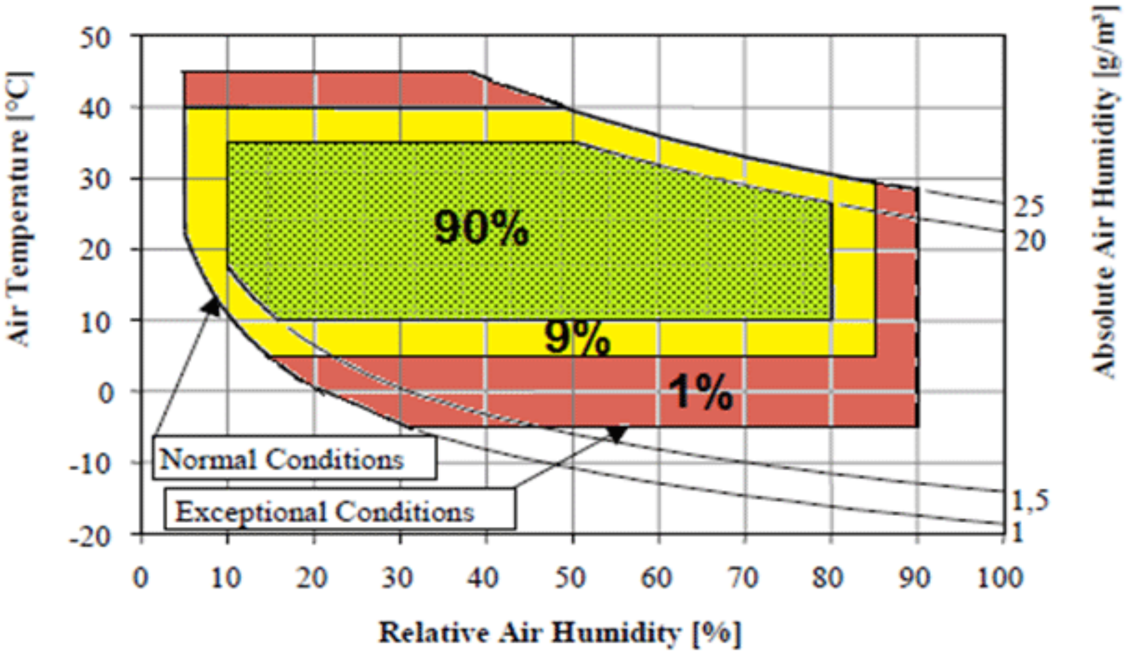
- Chiller Hours Per Year for Air-side Economization (US Cities)



Backup

ETSI

8 Final draft ETSI EN 300 019-1-3 V2.3.2 (2009-07)



Values outside this field have a probability of occurrence of less than 10 % (see IEC 60721-3-0).

Exceptional climatic limits.

Normal climatic limits: Values outside these limits have a probability of occurrence of less than 1 % .

NOTE: Exceptional conditions may occur following the failure of the temperature controlling system. This is described as 3.1E in the tables but it should be noted that there is no separate class 3.1E.

ASHRAE Environmental Classes

2011	2008	Applications	IT Equipment	Environmental Control
A1	1	**Datacenter**	Enterprise servers, storage products	Tightly controlled
A2	2		Volume servers, storage products, personal computers, workstations	Some control
A3	NA		Volume servers, storage products, personal computers, workstations	Some control
A4	NA		Volume servers, storage products, personal computers, workstations	Some control
B	3	Office, home, transportable environment, etc.	Personal computers, workstations, laptops, and printers	Minimal control
C	4	Point-of-sale, industrial, factory, etc.	Point-of-sale equipment, ruggedized controllers, or computers and PDAs	No control

2011 Thermal Guidelines – Power and Airflow

- Power – ITE thermal management drives air movers to cool components
  - Air movers, some silicon devices consume more power with elevated temperature
- Airflow required not linear with temperature