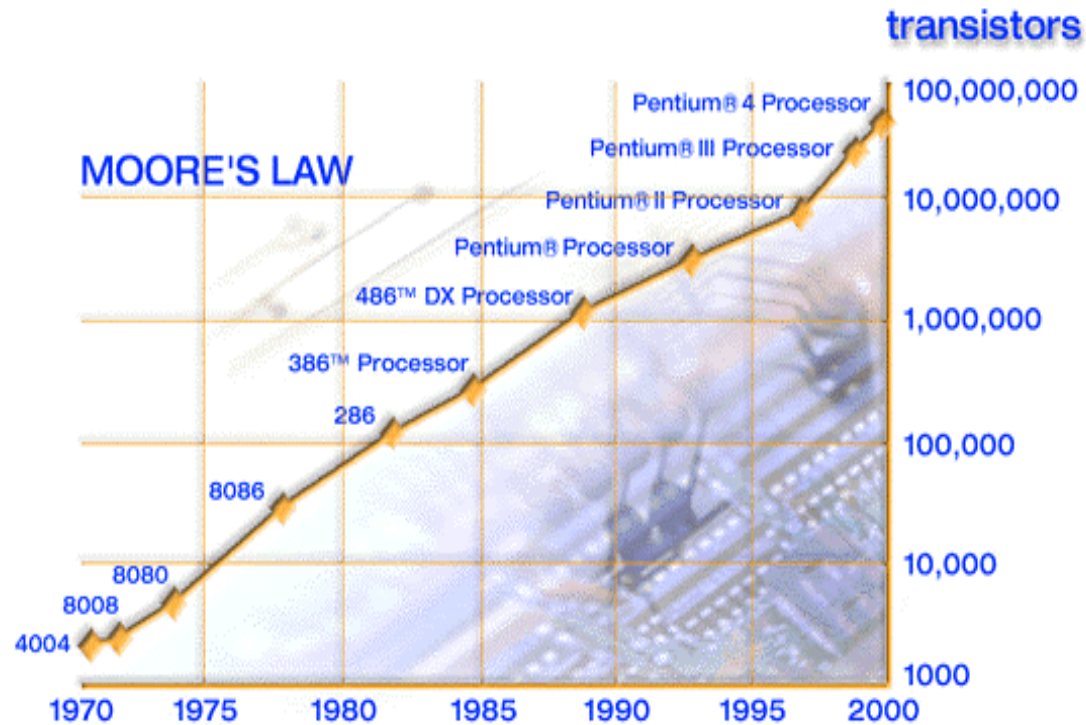




# Energy Saving Opportunities in Data Centers

David Poetker, PE Coffman Engineers  
Doug Bors, PE Cone Twelve

# Microprocessor Performance & Power Trends

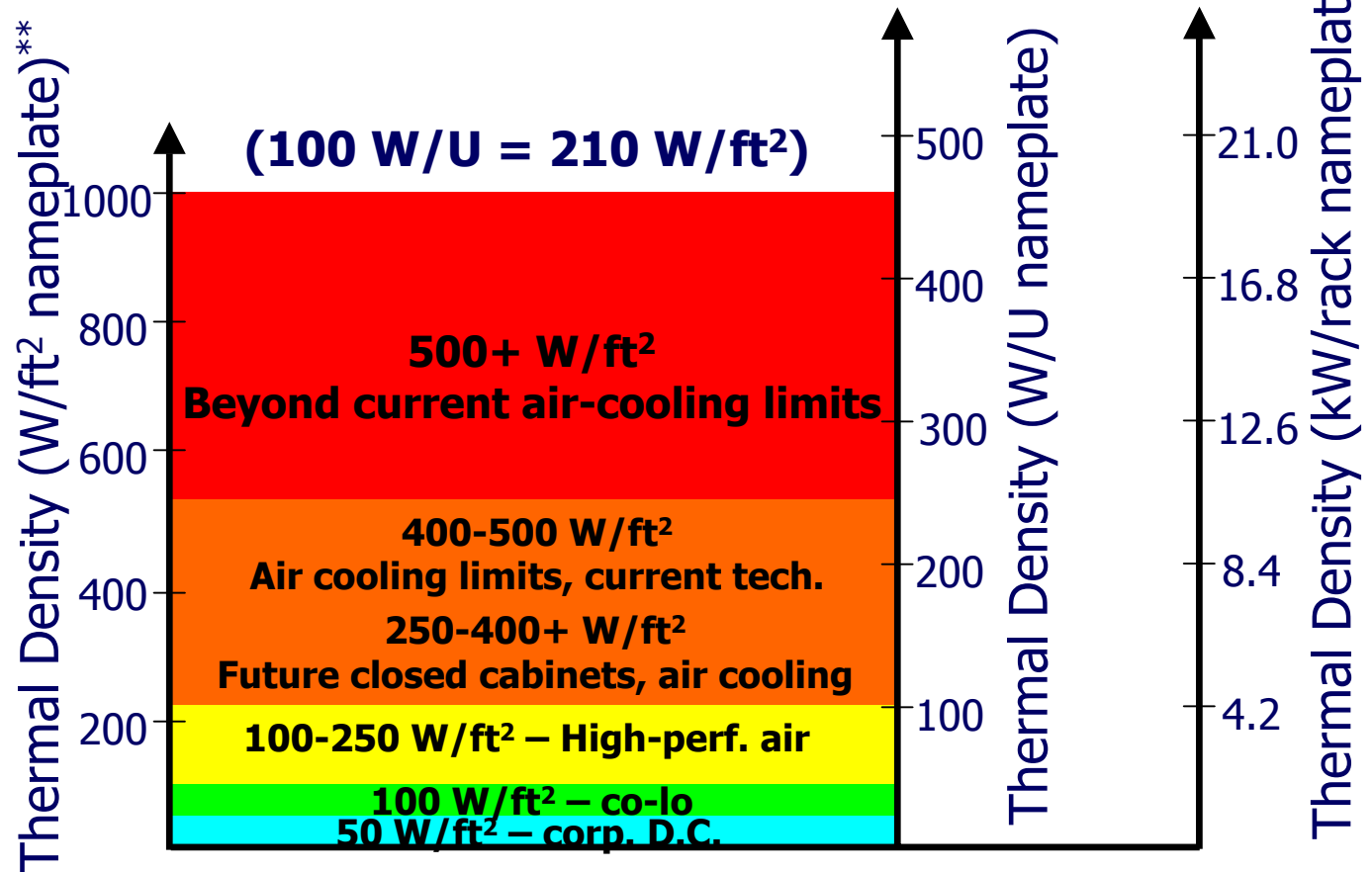


Transistor Density

Source: Intel Corporation

# Server Thermal Footprints

Horizontal, rack-mounted server form factors



\* Assumes 42U/rack populated with these systems

\*\* Allocates industry-standard 20 ft²/rack, no de-rating



# The Thermal Challenge

- Thermal load densities will continue to grow.
- Data Centers in the 150 watts/sf to 300 watts/sf will become more common in the future.
- Limits of air cooling technology will be approached.
- Increasing difficulty in providing economizer systems for Data Centers in high-rise buildings.

# 2000 State Energy Code

2000 EDITION

## CHAPTER 14 BUILDING MECHANICAL SYSTEMS

**1401 Scope:** This section covers the determination of requirements, system and component performance, control requirements and duct construction.

**EXCEPTION:** Special applications, including but not limited to hospitals, laboratories, thermally sensitive equipment and rooms designed to comply with the special construction and fire protection requirements of NFPA 75, "Standard for the Protection of Electronic Computer/Data Processing Equipment" may be exempt from the requirements of this section when approved by the building official. Exemptions shall be specific on a case-by-case basis and allowed only to the extent necessary to accommodate the special applications.

**1402 Mechanical Ventilation:** The minimum requirements for ventilation shall comply with the

Washington State Ventilation and Indoor Air Quality Code (WAC 51-13).

### SECTION 1410 – GENERAL REQUIREMENTS:

The building mechanical system shall comply with Sections 1411 through 1416, Sections 1440 through 1443, Sections 1450 through 1454, and with one of the following paths:

- a. Simple Systems (Packed Unitary Equipment), Sections 1420 through 1424
- b. Complex Systems, Sections 1430 through 1439
- c. Systems Analysis. See Section 1141.4

# 2000 State Energy Code

**1401 Scope:** This section covers the determination of requirements, system and component performance, control requirements and duct construction.

**EXCEPT:** Special applications including but not limited to health laboratories, highly sensitive equipment and mission-critical applications shall comply with the special construction and fire protection requirements of NFPA 75, "Standard for the Protection of Electronic Computer/Data Processing Equipment." Any deviation from the requirements shall be approved by the building official. Exemptions shall be specified on a case-by-case basis and shall be limited only to the extent necessary to accommodate the special applications.

# 2001 State Energy Code

(Effective July 1, 2002)

2001 EDITION

## CHAPTER 14 BUILDING MECHANICAL SYSTEMS

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- c. Systems Analysis. See Section 1411.4

# 2001 State Energy Code

## (Effective July 1, 2002)

### 1413 Economizers

**1413.1 Operation:** Air economizers shall be capable of automatically modulating outside and return air dampers to provide 100% of the design supply air as outside air to reduce or eliminate the need for mechanical cooling. Air economizers shall be used for RS-29 analysis base case for all systems without exceptions in Sections 1413, 1423, or 1433. Water economizers shall be capable of providing the total concurrent cooling load served by the connected terminal equipment lacking airside economizer, at outside air temperatures of 45°F dry-bulb/40°F wet-bulb and below. For this calculation, all factors including solar and internal load shall be the same as those used for peak load calculations, except for the outside temperatures.

**EXCEPTION:** Water economizers using air-cooled heat rejection equipment may use a 35 F dry-bulb outside air temperature for this calculation. This exception is limited to a maximum of 20 tons per building.

**1413.2 Documentation:** Water economizers plans submitted for approval shall include the following information:

1. Maximum outside air conditions for which economizer is sized to provide full cooling.
2. Design cooling load to be provided by economizer at this outside air condition.
3. Heat rejection and terminal equipment performance data including model number, flow rate, capacity, entering and leaving temperature in full economizer cooling mode.

**1413.3 Integrated Operation:** The HVAC system and its controls shall allow economizer operation when mechanical cooling is required simultaneously. Air and water economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

**EXCEPTIONS:** 1. Individual, direct expansion units that have a rated capacity less than 65,000 Btu/h and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.

2. Water-cooled water chillers.

**1413.4 Humidification:** If an air economizer is required on a cooling system for which humidification equipment is to be provided to maintain minimum indoor humidity levels, then the humidifier shall be of the adiabatic type (direct evaporative media or fog atomization type) that cools return air while humidifying outside air while in economizer. If a water economizer or no economizer is provided, the isothermal type of humidifier may be used (steam injection, gas, electric resistance or infrared generator type that uses new energy to boil moisture to be added).

**EXCEPTION:** Health care facilities where WAC 246-320-525 allows only steam injection humidifiers in ductwork downstream of final filters.

# 2001 State Energy Code

## (Effective July 1, 2002)

**1433 Economizers:** Air economizers meeting the requirements of Section 1413 shall be provided on all new systems including those serving computer server rooms, electronic equipment, radio equipment, telephone switchgear.

**EXCEPTIONS:** 1. Single package unitary fan-cooling units installed outdoors or in a mechanical room adjacent to outdoors with a total cooling capacity less than 20,000 Btu/h. Other single package unitary fan-cooling units with a total cooling capacity less than 54,000 Btu/h. The total capacity of all such systems without economizers shall not exceed 240,000 Btu/h per building, or 10% of its air economizer capacity, whichever is greater. That portion of the equipment serving Group R occupancy is not included

economizers in a building.

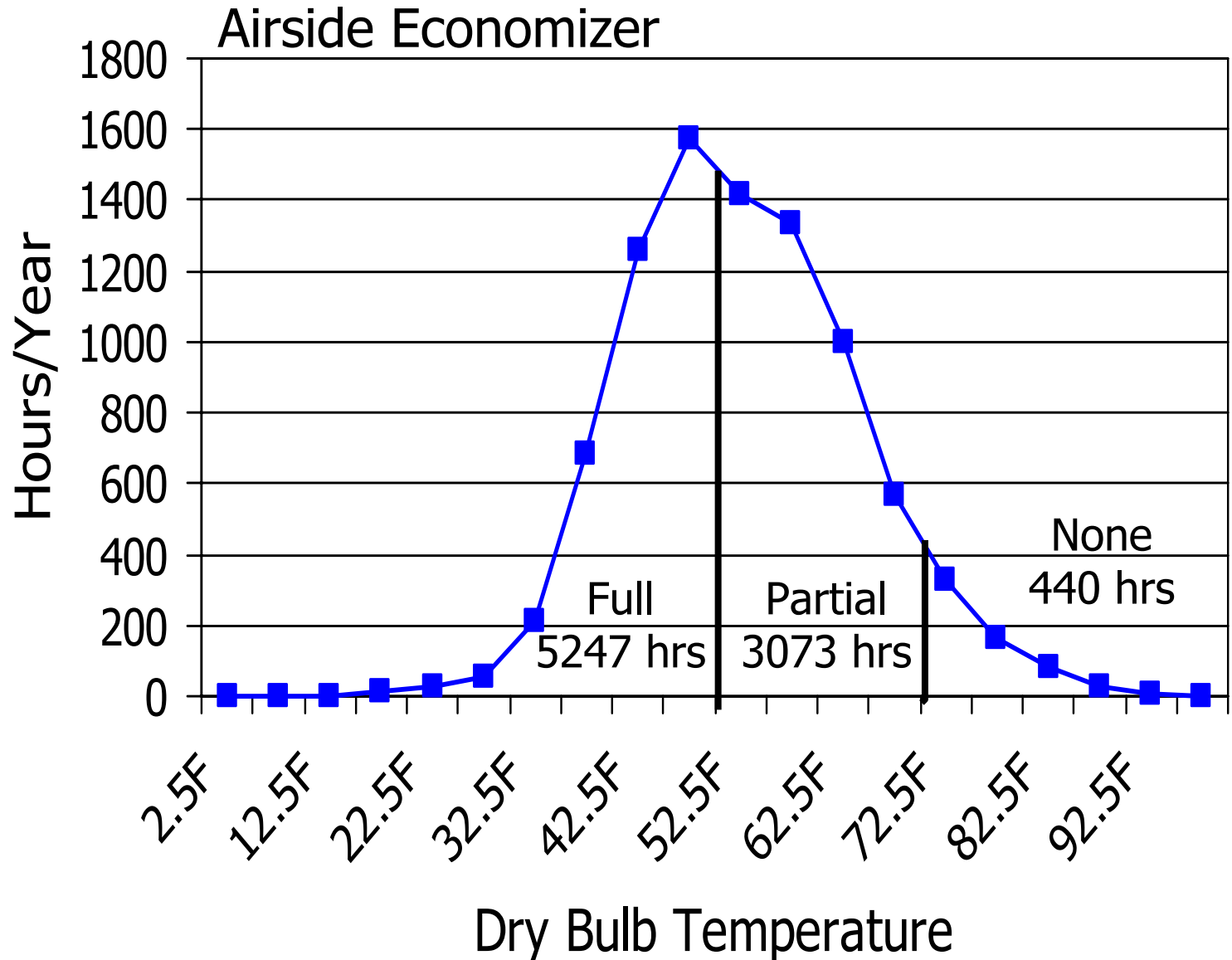
2. Water-cooled refrigeration equipment provided with a water economizer meeting the requirements of Section 1413. Water economizer capacity per building shall not exceed 500 tons. This exception shall not be used for RS-29 analysis.

3. Systems for which at least 75% of the annual energy used for mechanical cooling is provided from site-recovery or site-solar energy source.

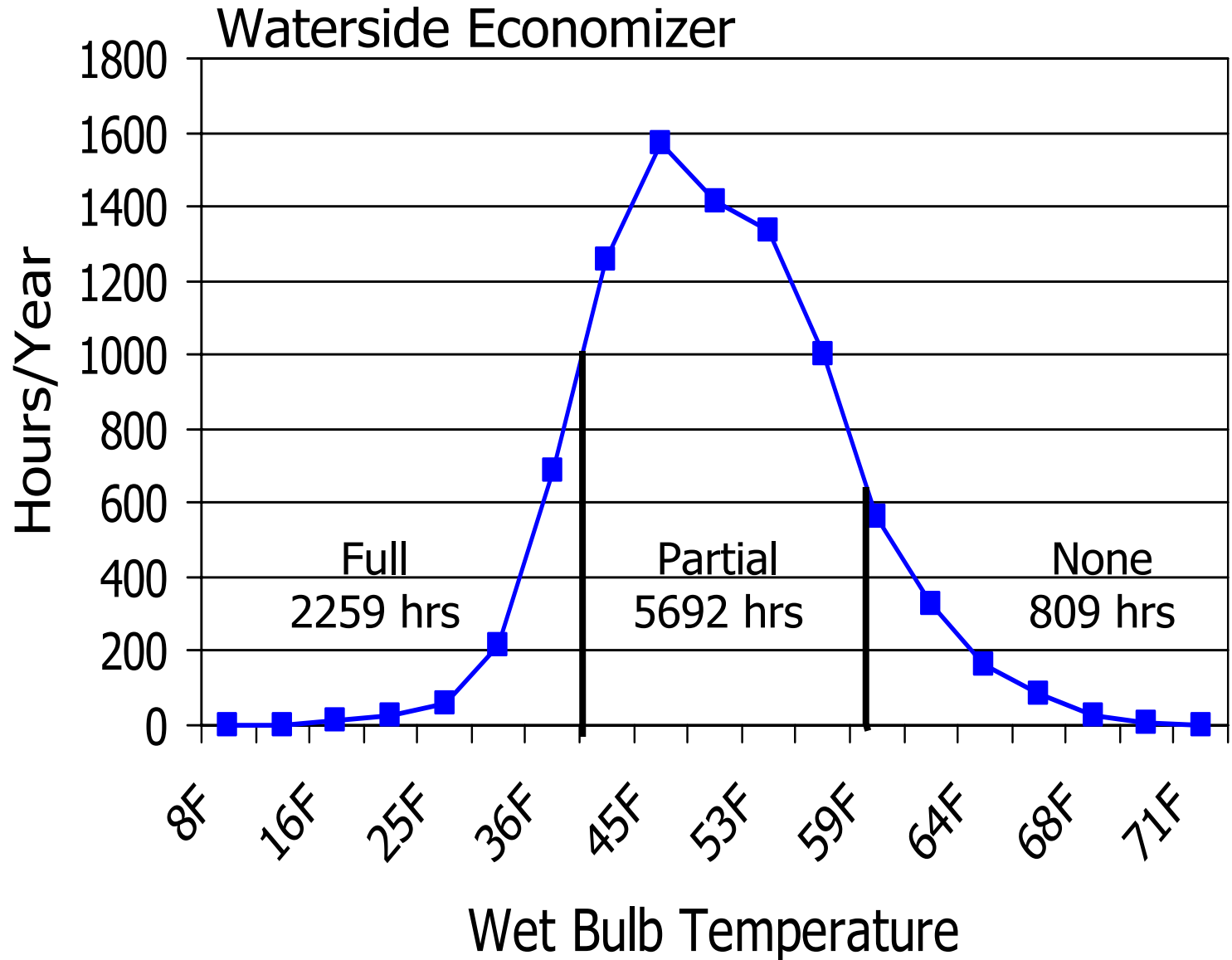
4. Systems where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes an air economizer infeasible.

5. Systems that affect other systems (such as dehumidification and supermarket refrigeration systems) so as to increase the overall building energy consumption. New humidification equipment shall comply with Section 1413.4.

# Seattle Weather Bin Data



# Seattle Weather Bin Data



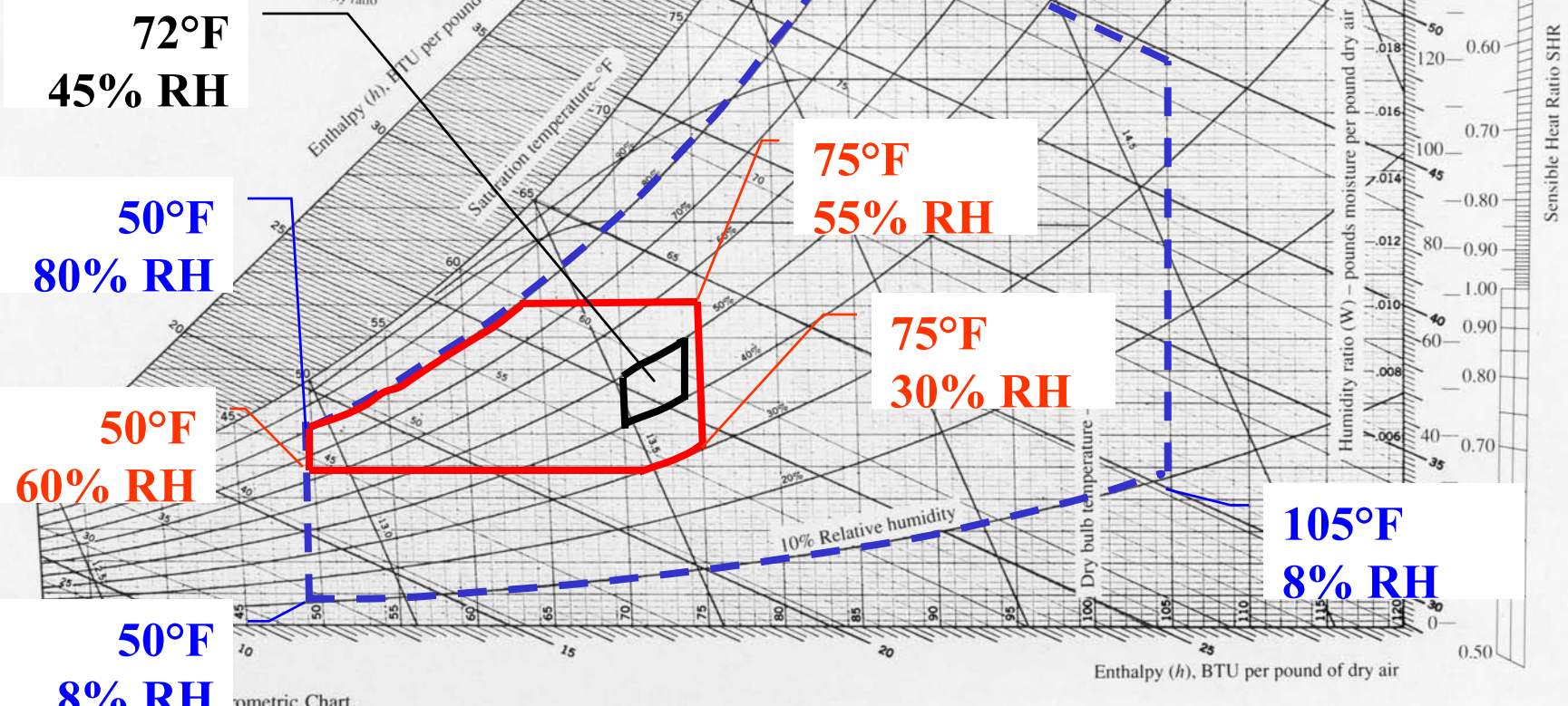
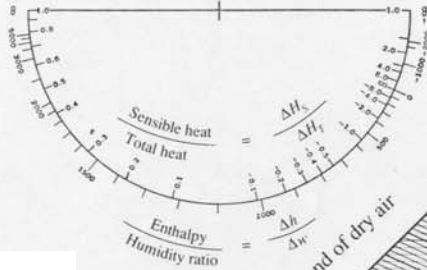


# Server Environment

- Manufacturer's Listed Operating Range:  
50°F to 105°F, 8% to 80% RH,  
81°F maximum wet bulb
- Reliability Range:  
72°F +/- 2°F (70°F to 74°F)  
45% RH +/- 5% (40% to 50%)  
(at face of server)

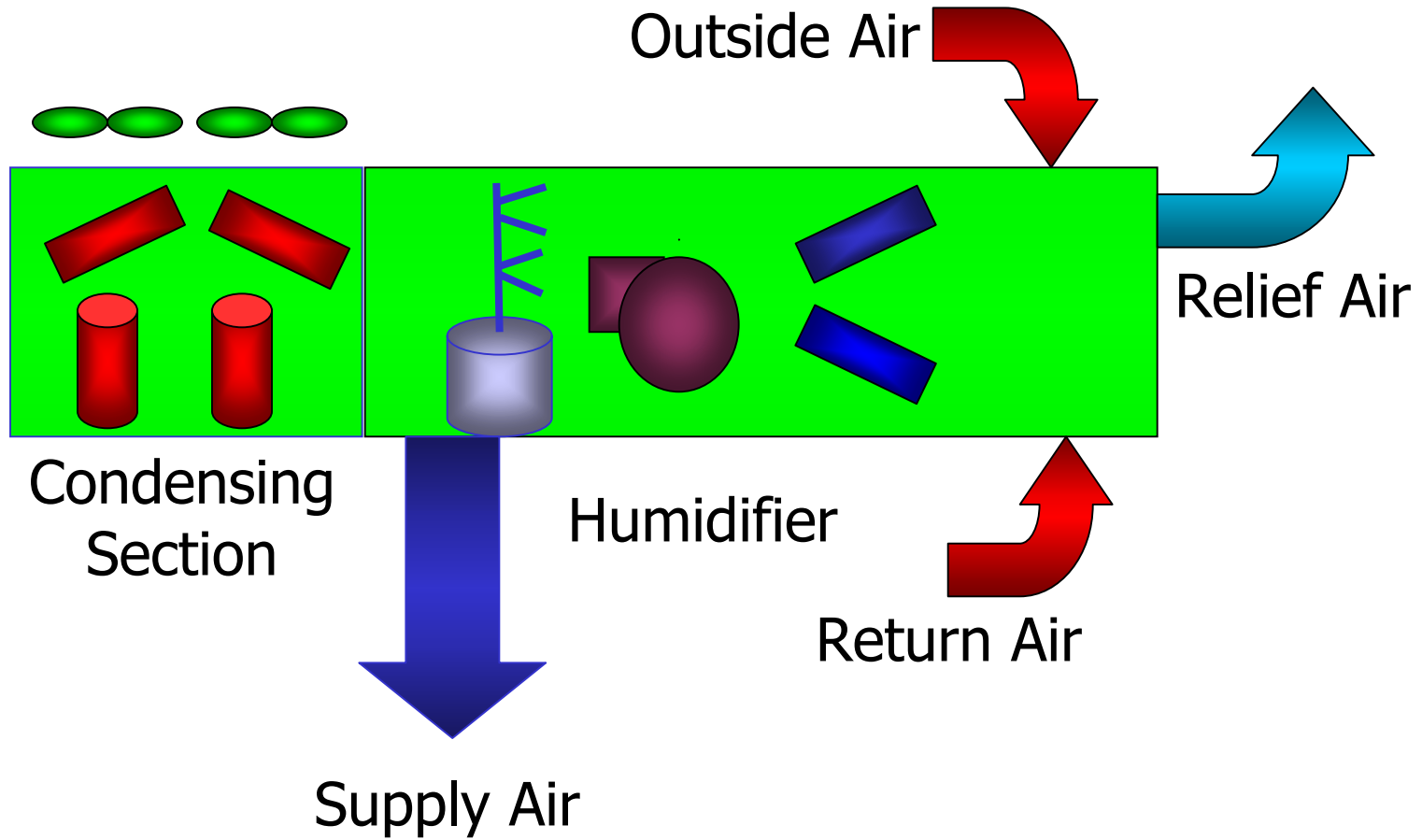
# Psychrometric Chart

ASHRAE Psychrometric Chart No. 1  
 Normal temperature  
 Barometric pressure 29.921 inches of mercury  
 Copyright 1963  
 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.



Based on ASHRAE Psychrometric Chart No. 1. Reprinted with permission from ASHRAE Inc.  
 Sensible heat ratio (SHR), humidity ratio scale in grains/lb, and two cooling and dehumidifying curves were added by author.

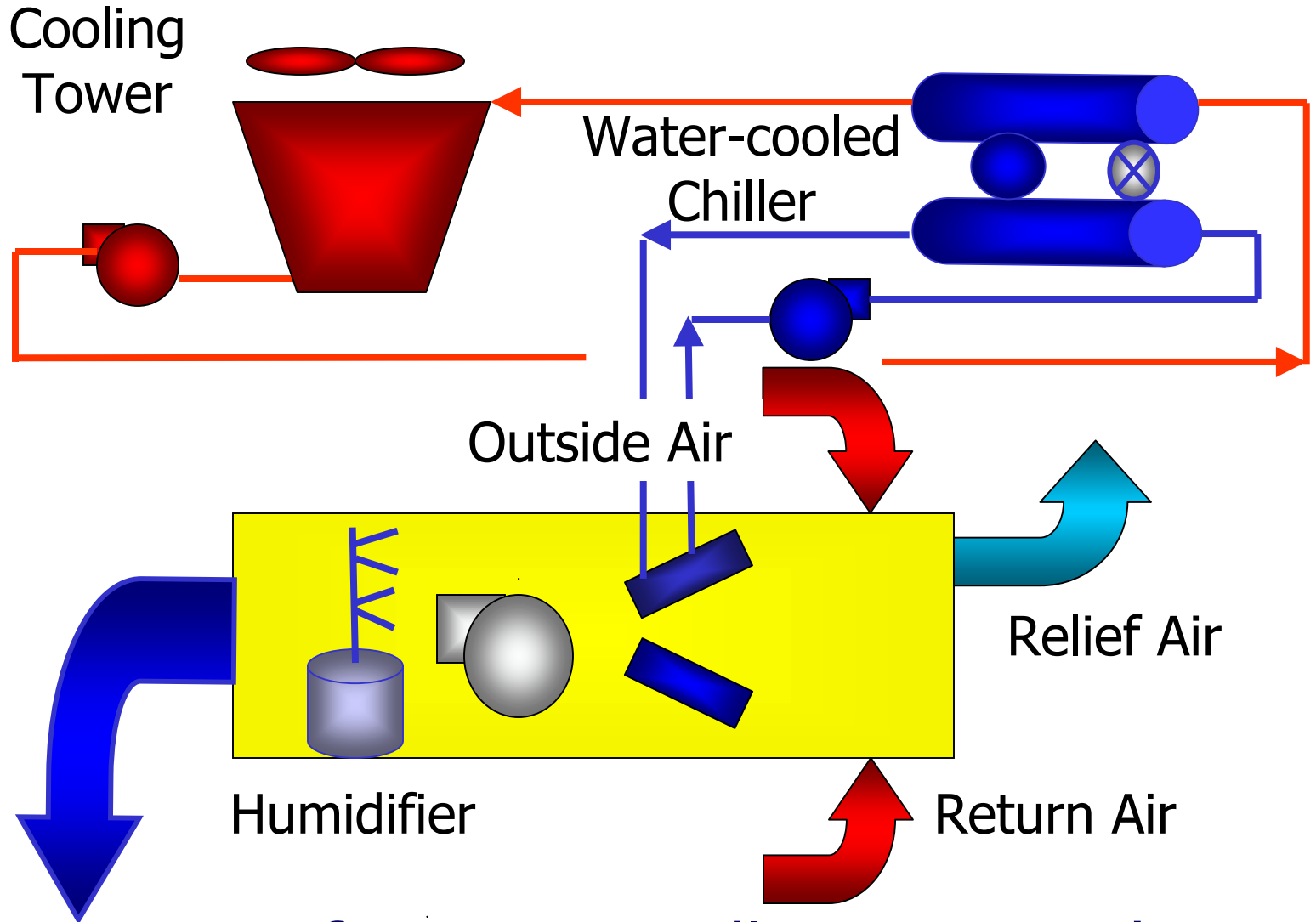
# Airside Economizer



Packaged Rooftop Air Conditioning Unit



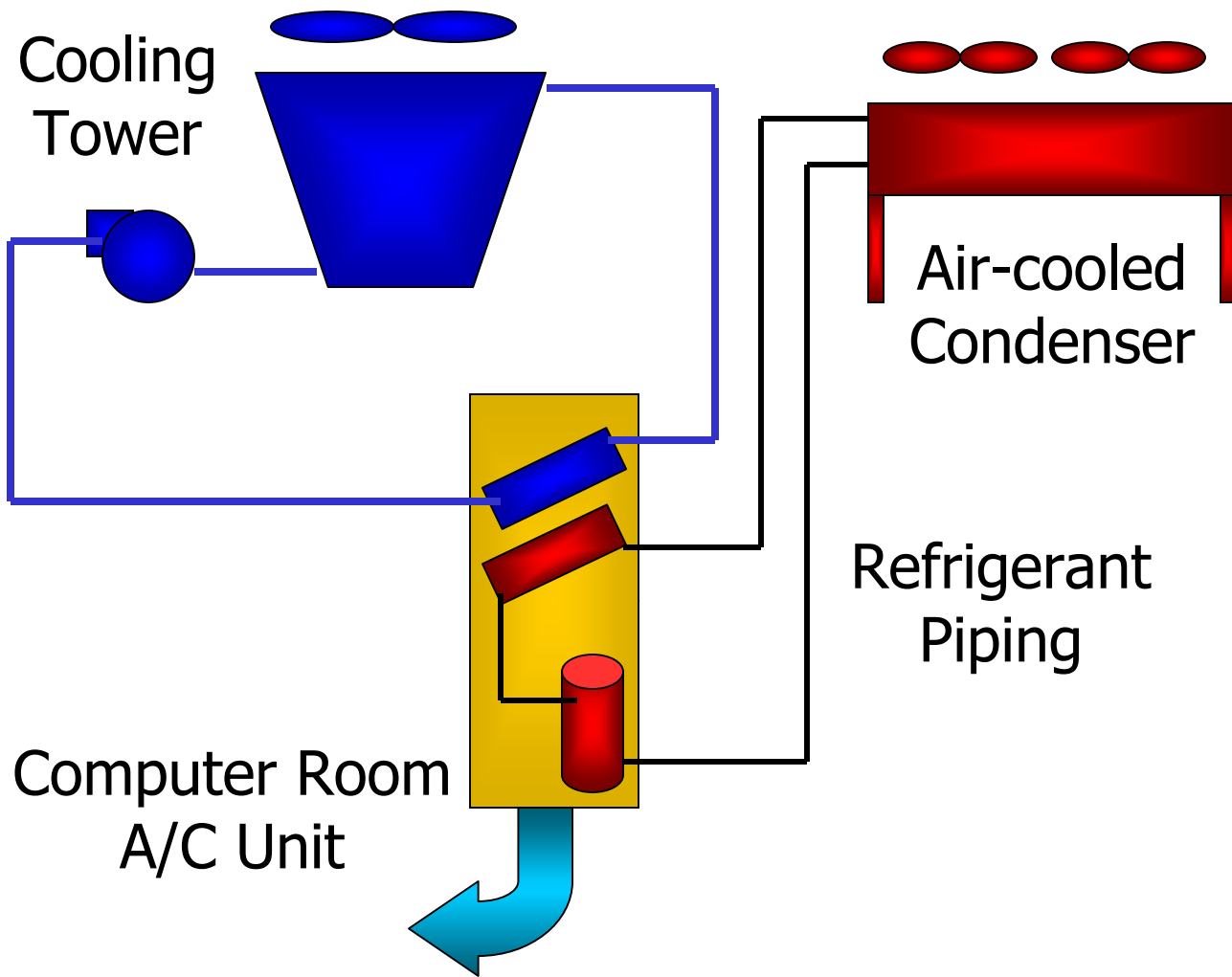
# Airside Economizer



Rooftop Air Handling Unit with Chilled Water System



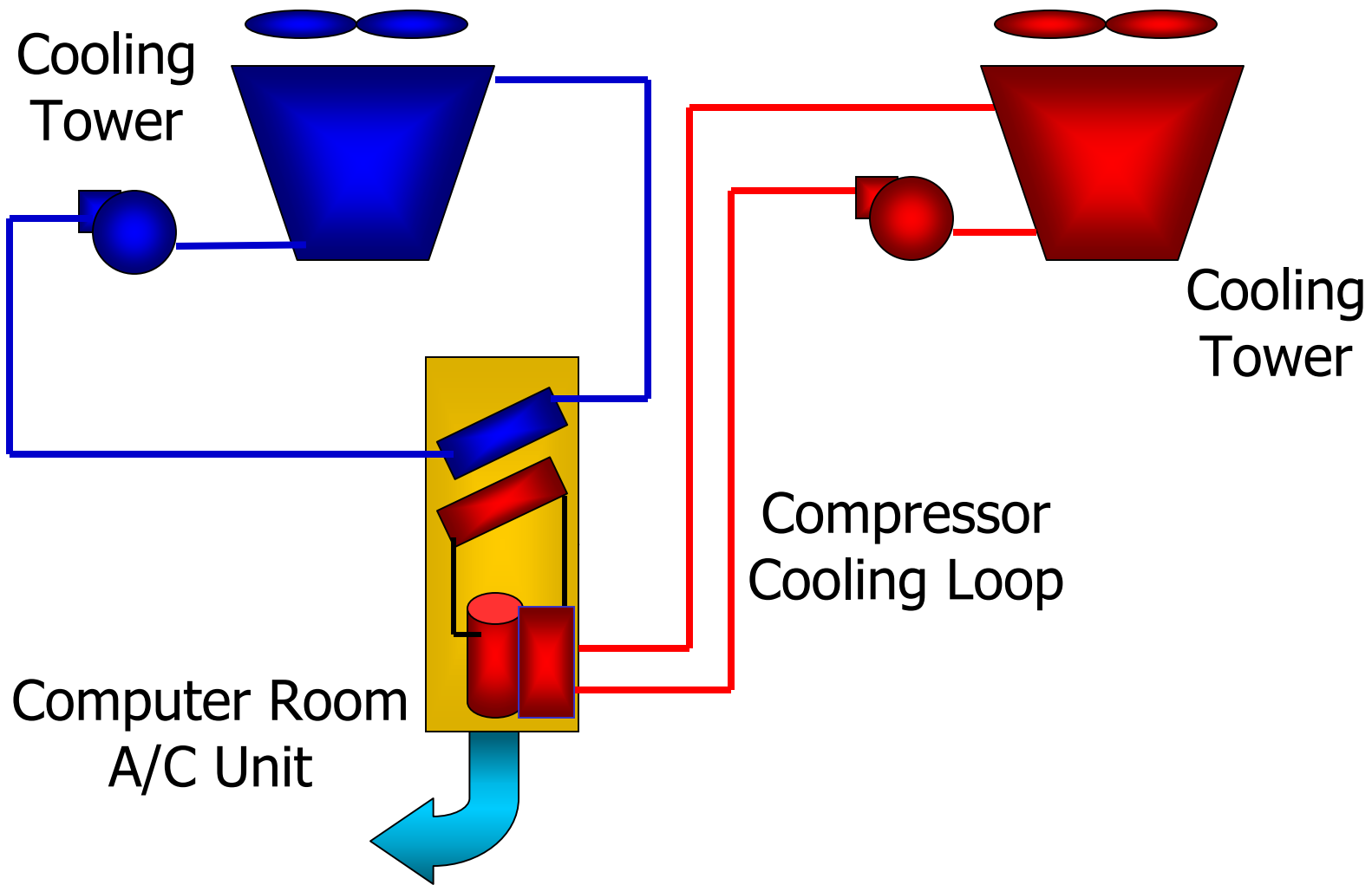
# Waterside Economizer



Air-cooled with Multiple Cooling Source

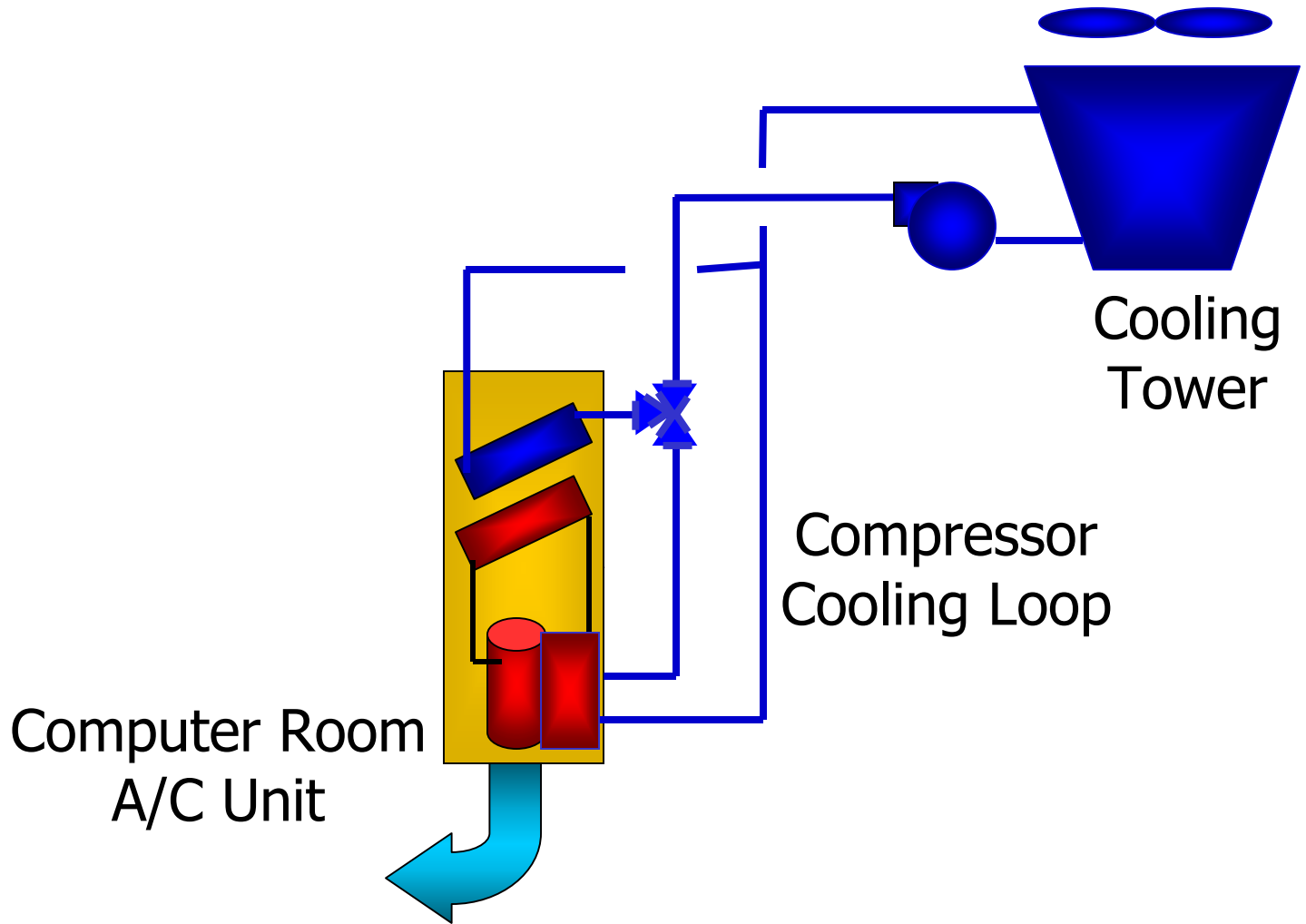


# Waterside Economizer



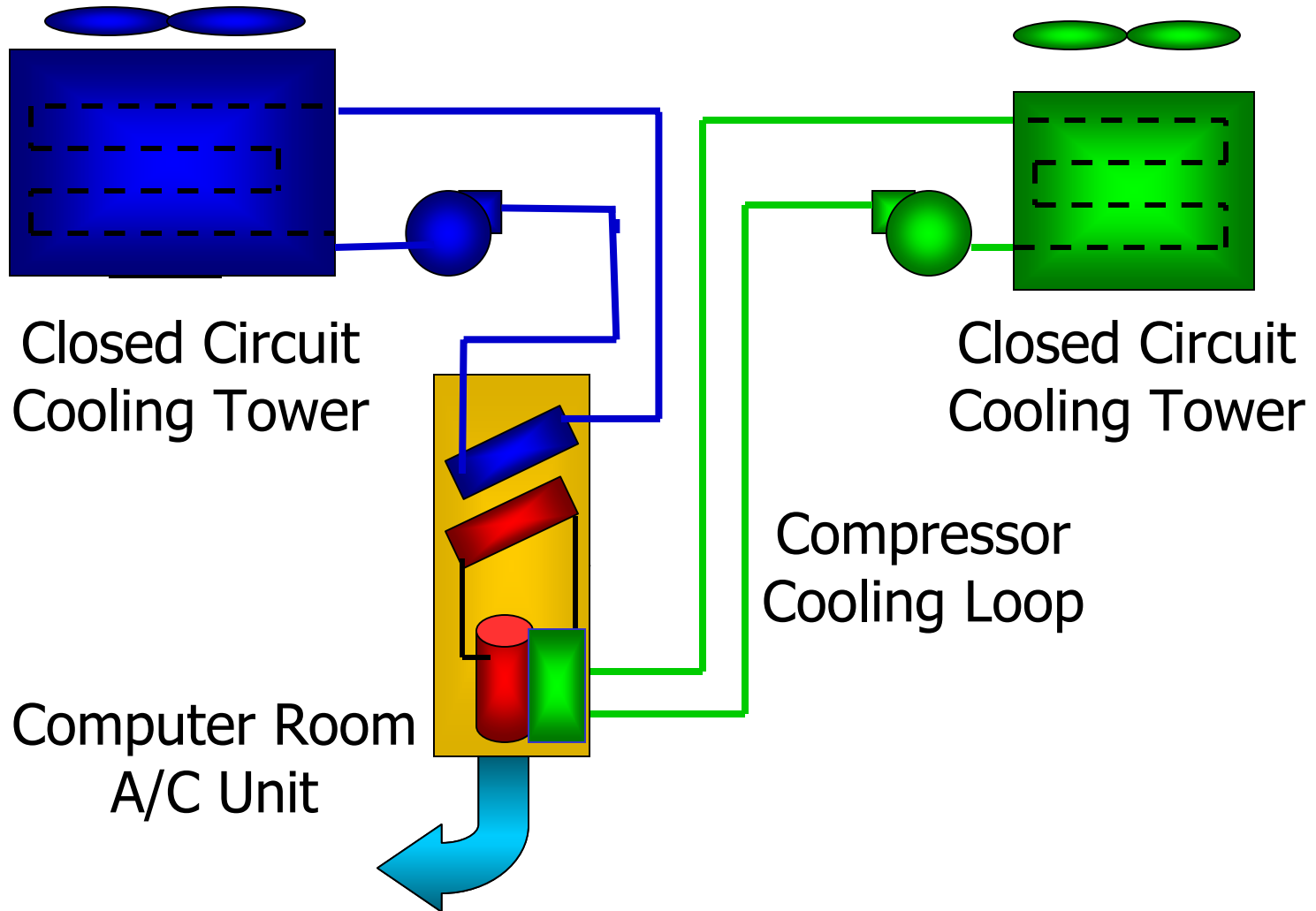
Water-cooled CRAC with Multiple Cooling Source

# Waterside Economizer



Water-cooled CRAC with Multiple Cooling Source

# Waterside Economizer



Closed Circuit Cooling Tower

Closed Circuit Cooling Tower

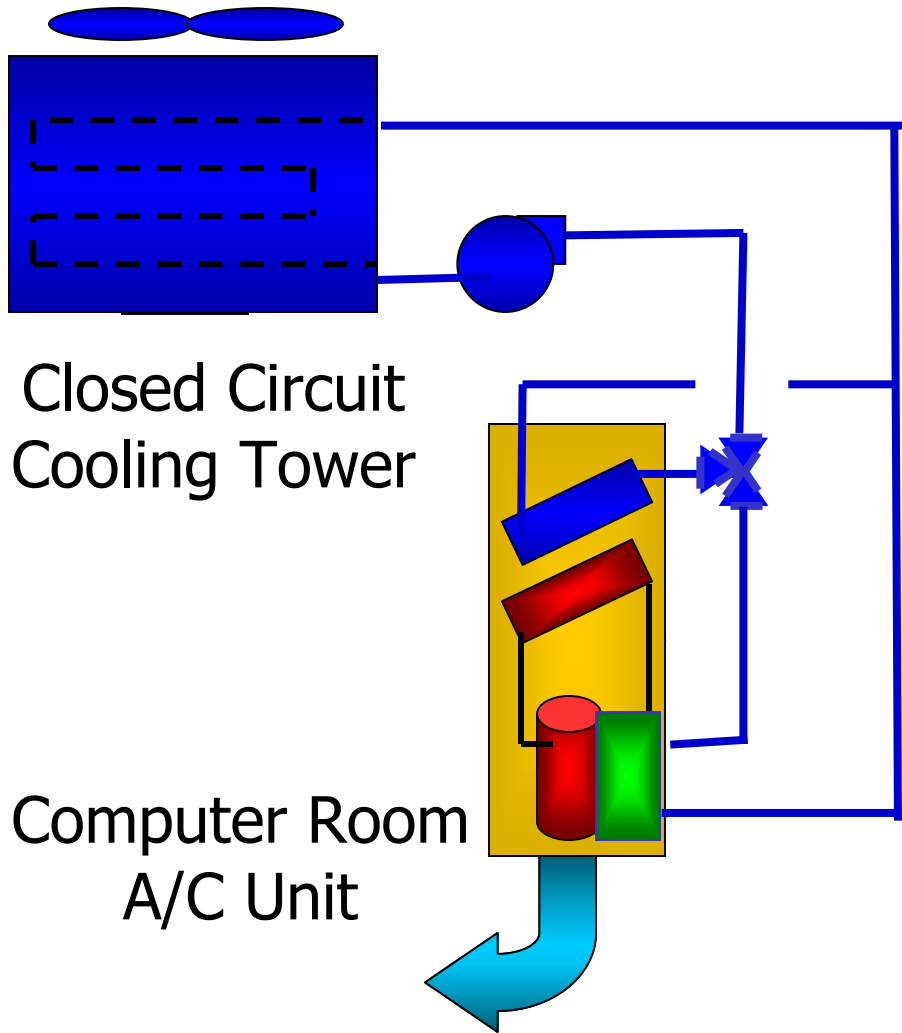
Computer Room A/C Unit

Compressor Cooling Loop

Glycol-cooled with Multiple Cooling Source



# Waterside Economizer



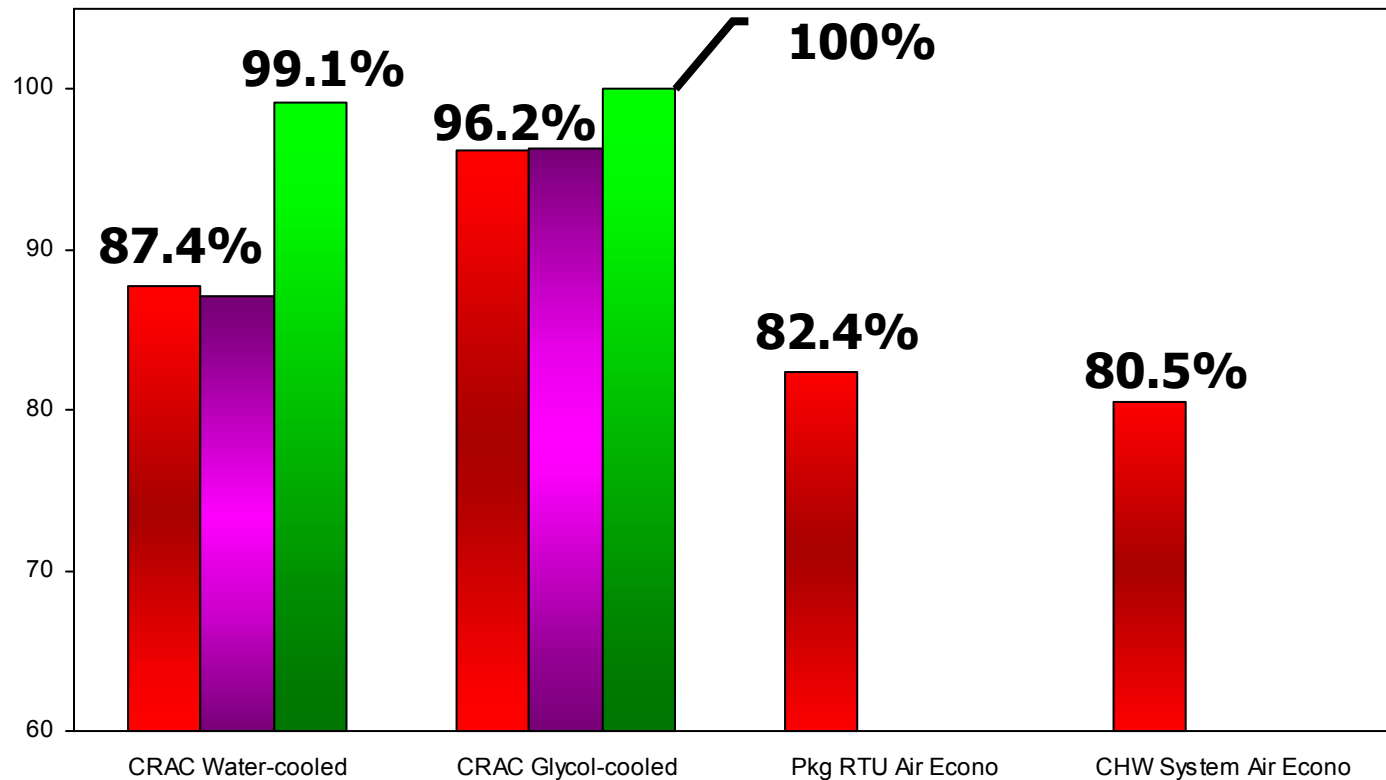
Closed Circuit  
Cooling Tower

Computer Room  
A/C Unit

Glycol-cooled with Multiple  
Cooling Source

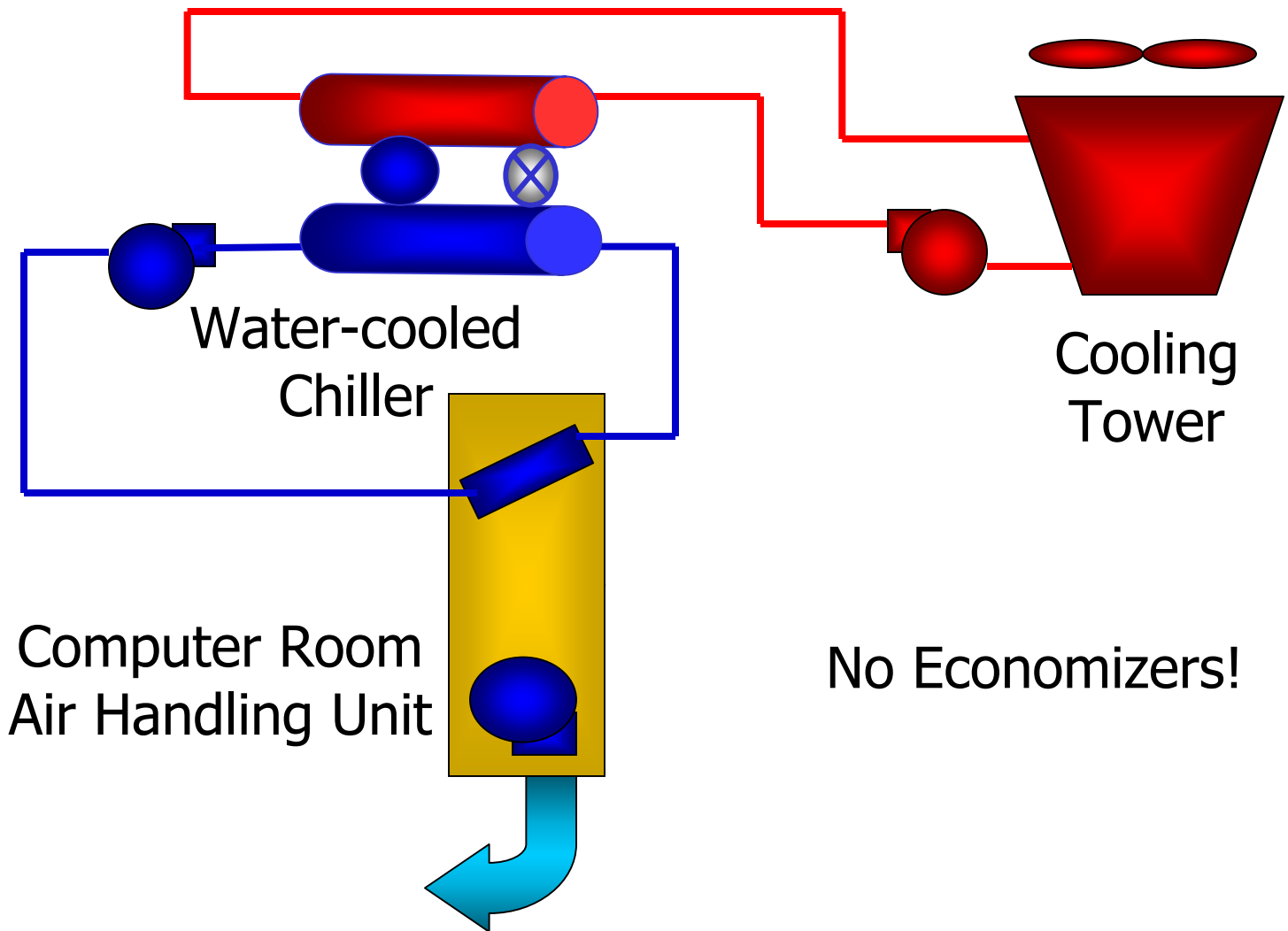
# Energy Comparisons of Systems

5,000 sf Data Center: 3.5 kW/rack (150 W/sf)  
8 floors from Data Center to Roof; Fully loaded



Baseline: Glycol-cooled CRAC No Economizer

# Chilled Water w/ CRAH Unit



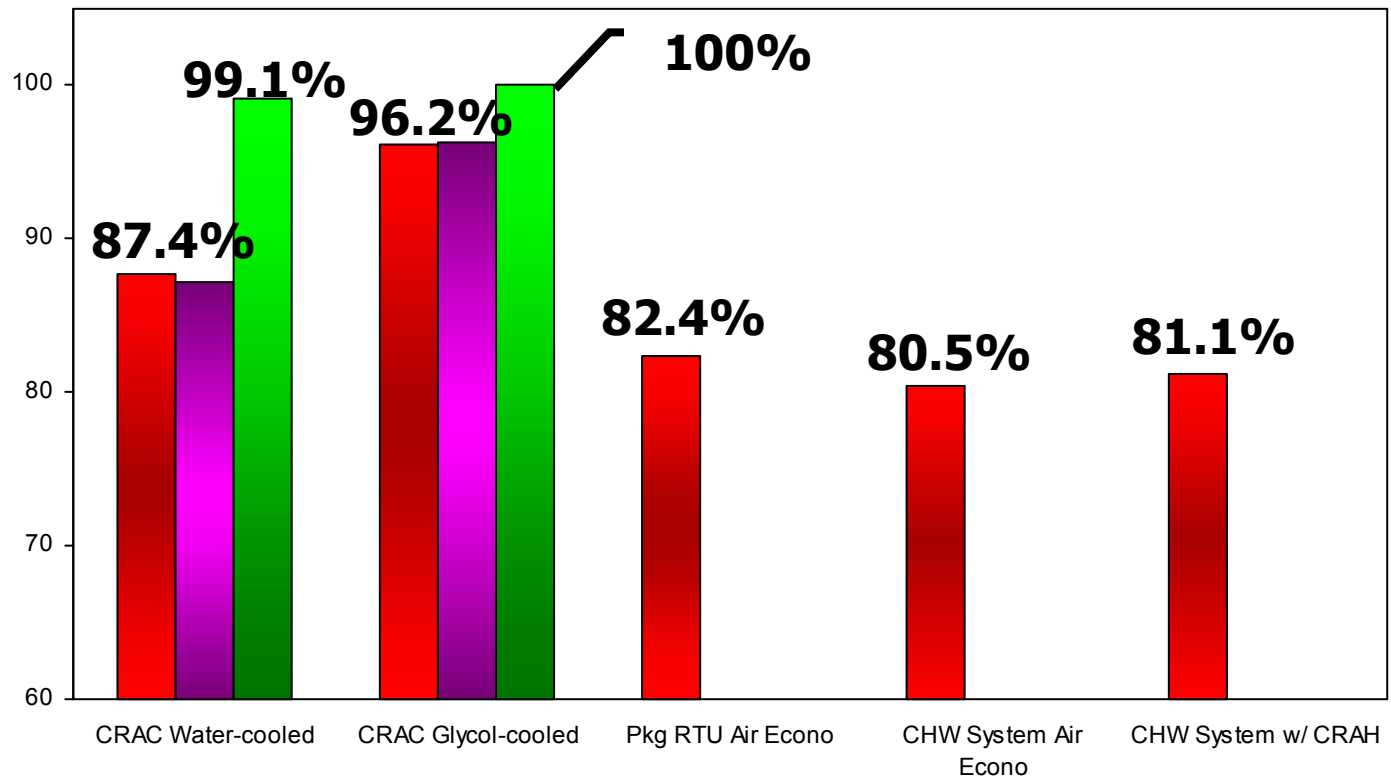
Computer Room  
Air Handling Unit

No Economizers!

## Water-cooled Chiller System with Computer Room Air Handling Unit

# Energy Comparisons of Systems

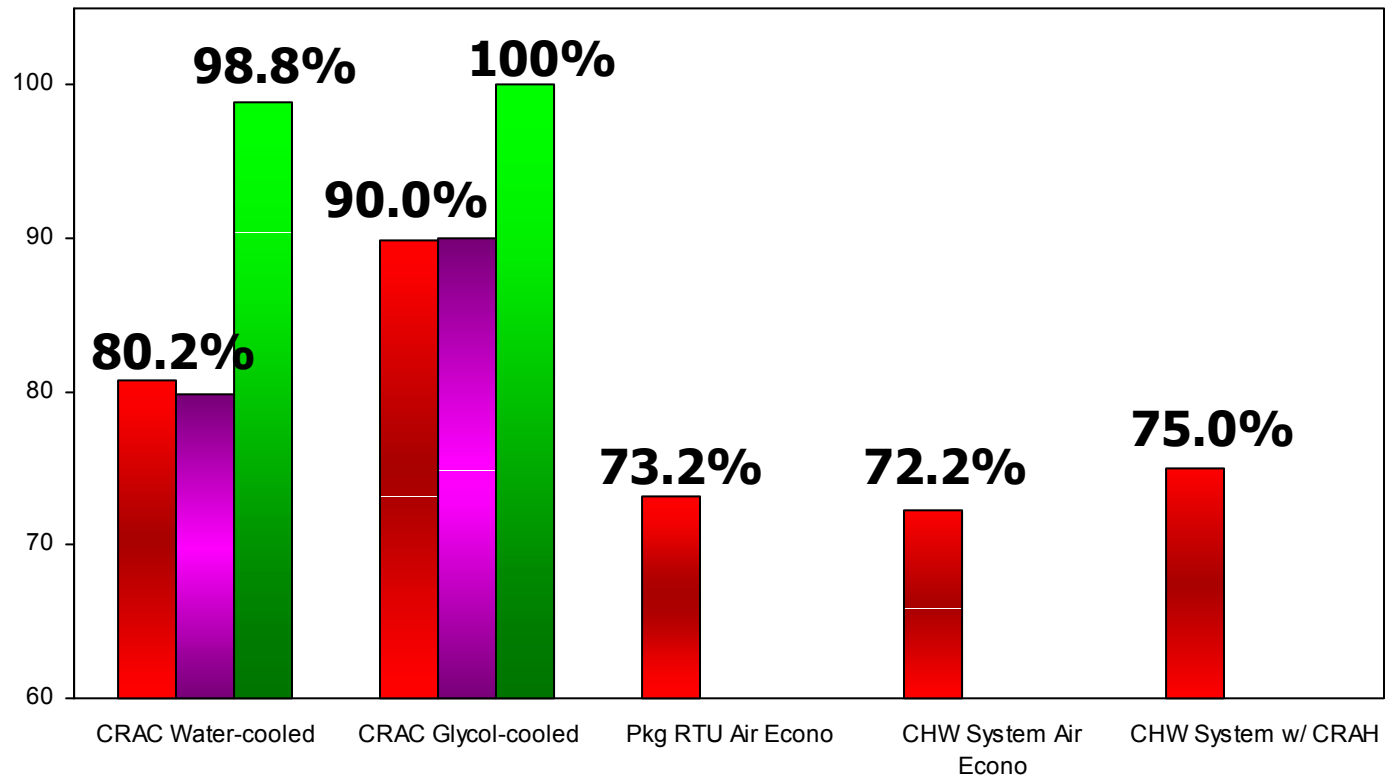
5,000 sf Data Center: 3.5 kW/rack (150 W/sf)  
8 floors from Data Center to Roof; Fully loaded



Baseline: Glycol-cooled CRAC No Economizer

# Energy Comparisons of Systems

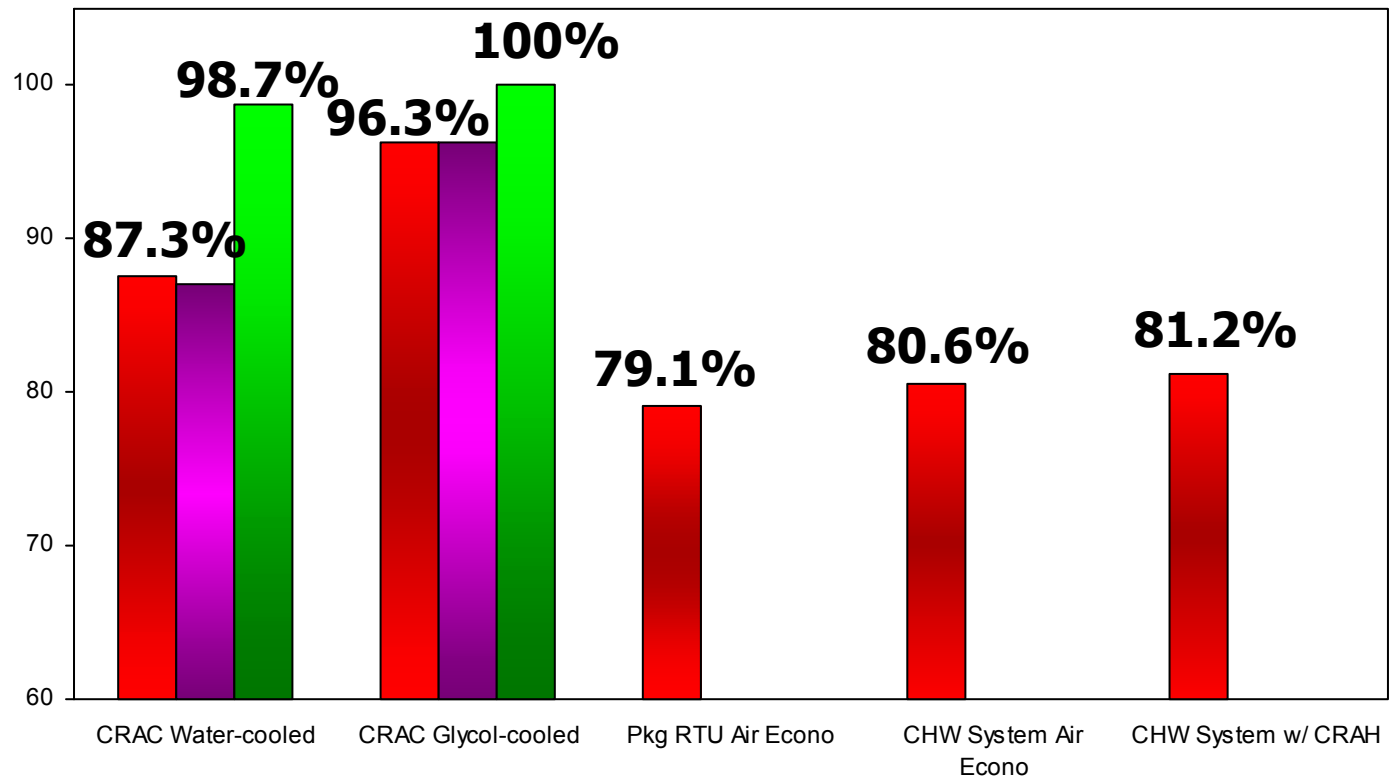
5,000 sf Data Center: 3.5 kW/rack (150 W/sf)  
8 floors from Data Center to Roof; 65% loaded



Baseline: Glycol-cooled CRAC No Economizer

# Energy Comparisons of Systems

5,000 sf Data Center: 3.5 kW/rack (150 W/sf)  
2 floors from Data Center to Roof; Fully loaded



Baseline: Glycol-cooled CRAC No Economizer

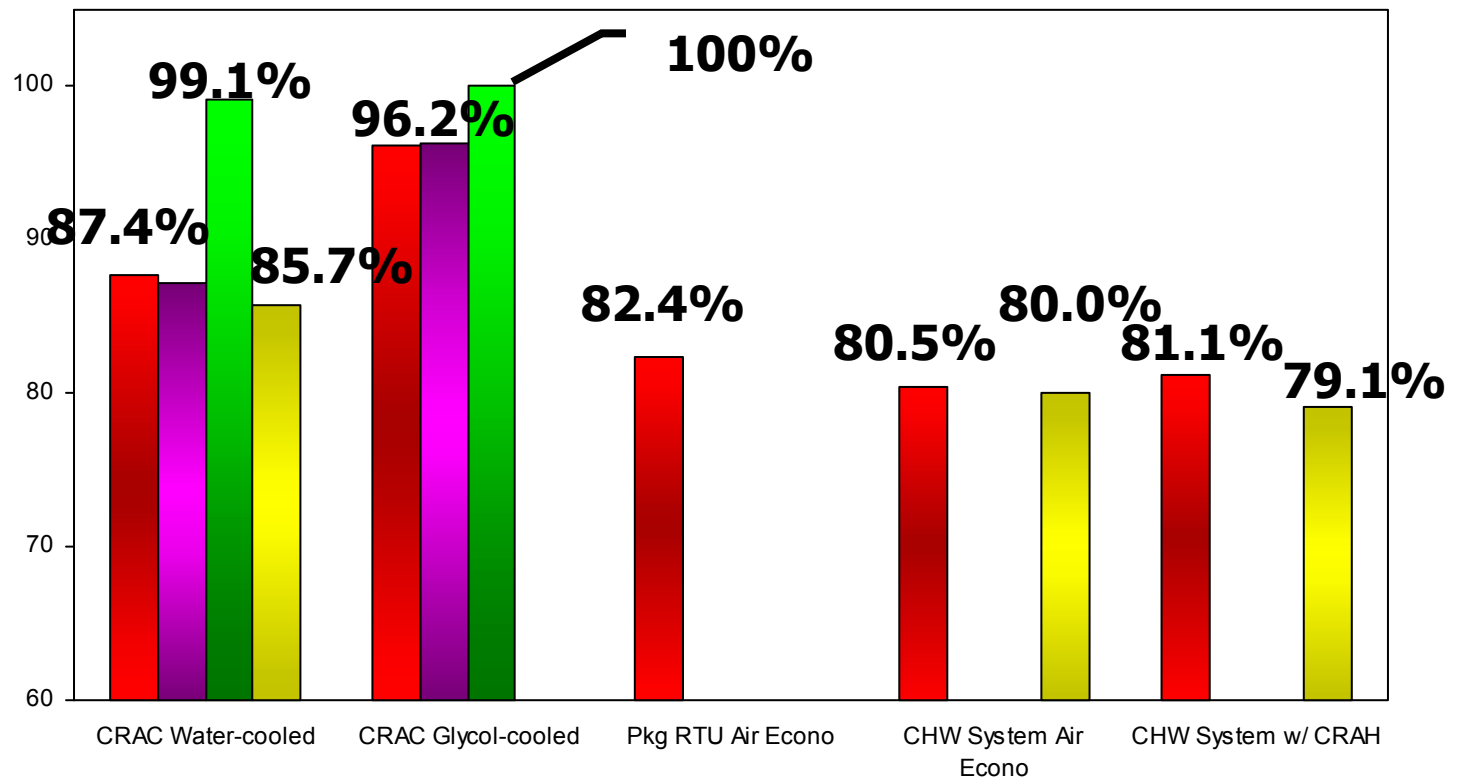


# Energy Savings in Equipment Selection

- Water-cooled CRAC: Larger cooling tower with smaller fan motor (30 HP vs. 50 HP)
- Chilled Water System for Both RTU and CRAH: More efficient chiller selection (0.564 kW/ton vs. 0.664 kW/ton)
- Chilled Water System for Both RTU and CRAH: Slightly larger cooling tower with smaller fan motor (7.5 HP vs. 10 HP)

# Results of Equipment Selection

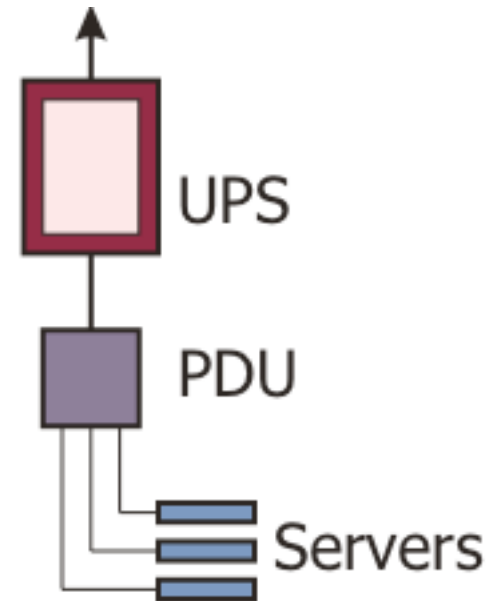
5,000 sf Data Center: 3.5 kW/rack (150 W/sf)  
8 floors from Data Center to Roof; Fully loaded



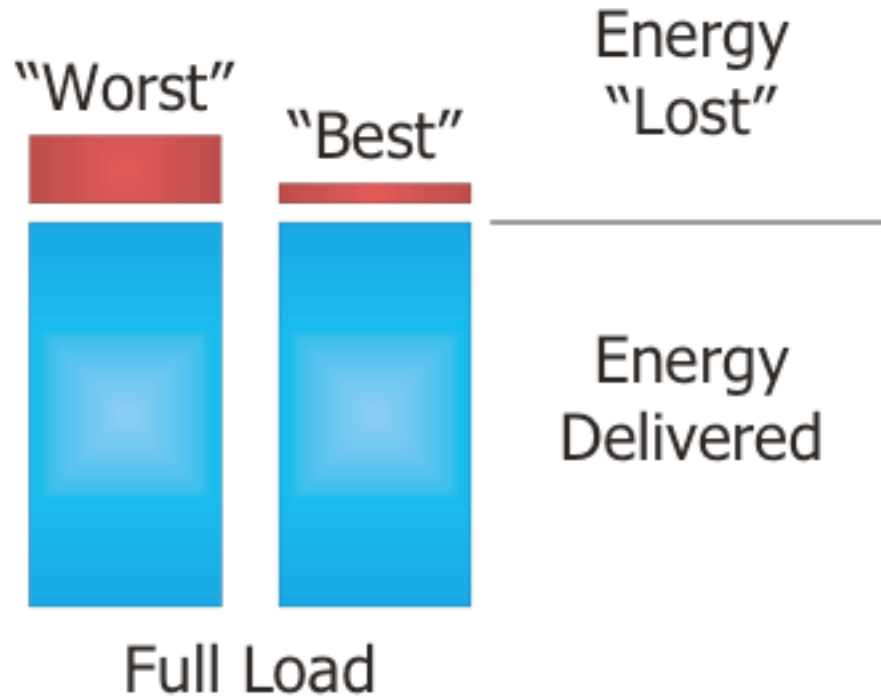
Baseline: Glycol-cooled CRAC No Economizer

# Electrical System Efficiency

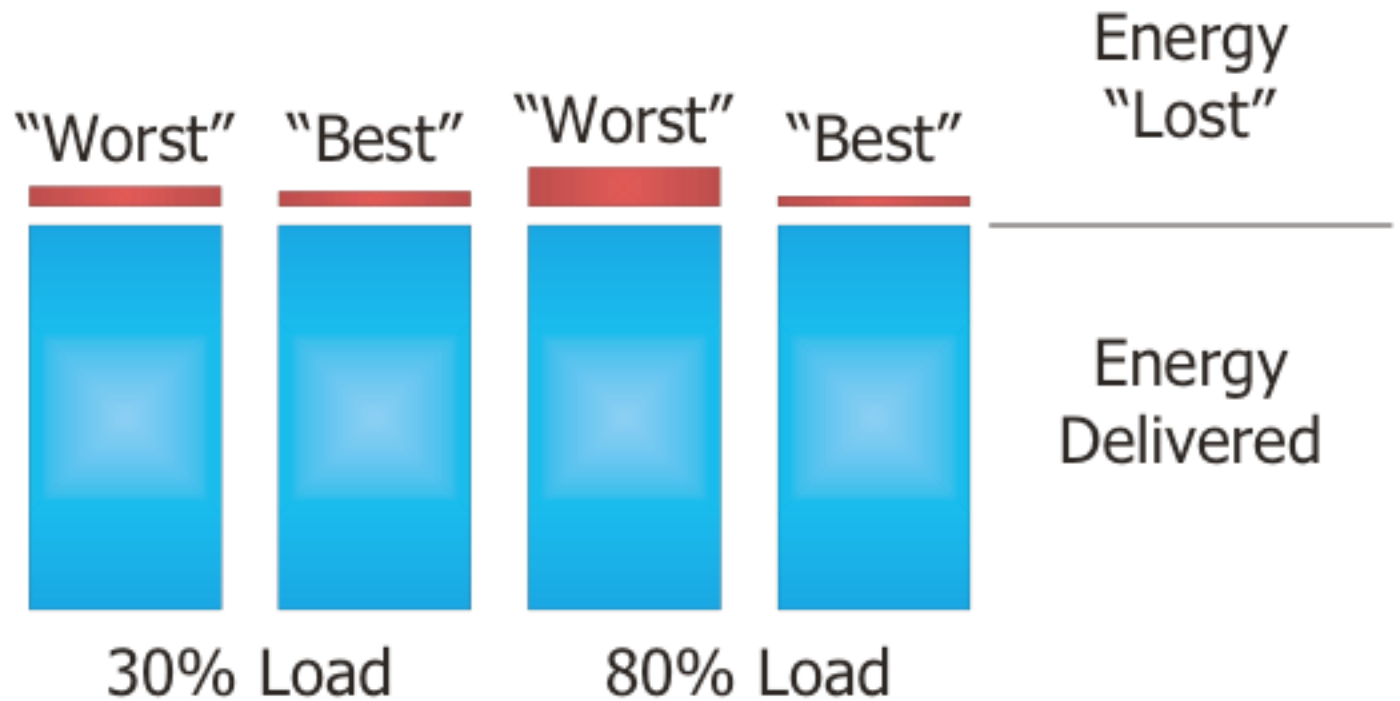
- UPS
- Distribution
- Power Supplies
- Trends
- Reliability + Energy



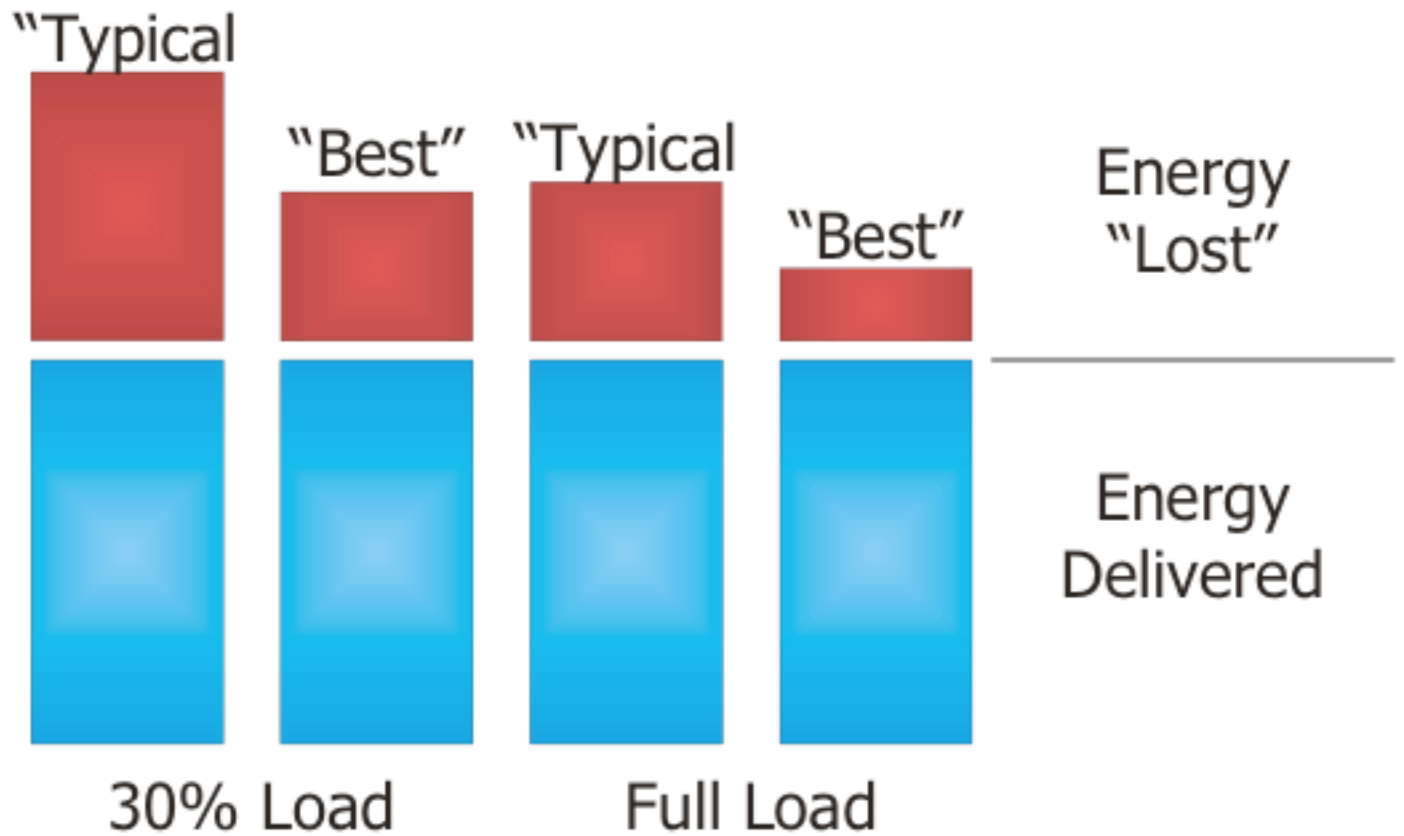
# UPS Energy Flow



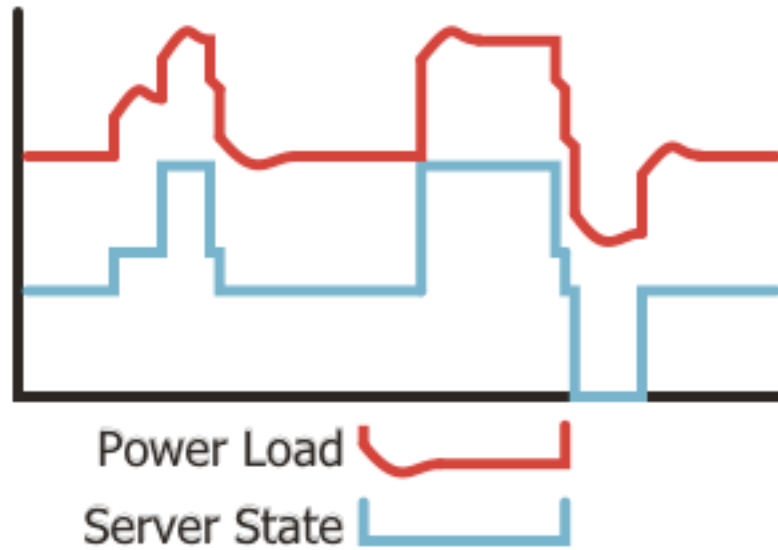
# 208 V Distribution Energy Flow



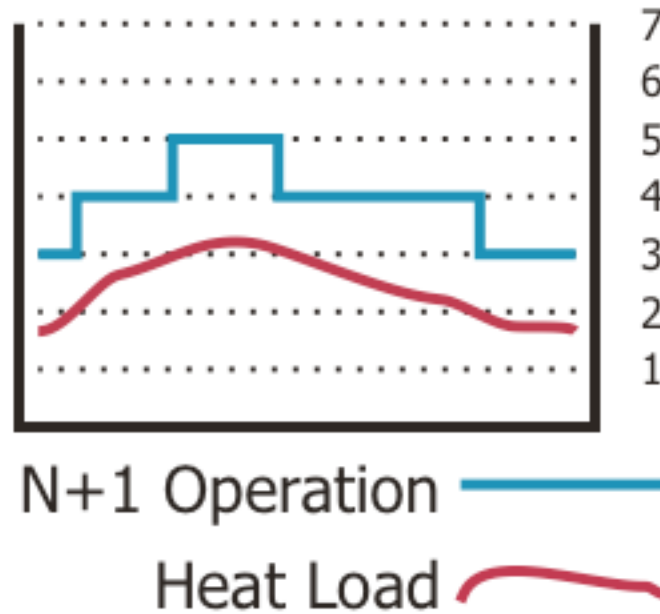
# Power Supply Energy Flow



# Trend: Power + Computation



# Operation: Reliability + Energy



# Solutions (Review)

