IEEE

Morrison Hershfield
Mission Critical

Data Center Trends And Design

Steven Shapiro
Critical Facilities Practice Lead

Data Center Trends & Design

Agenda

- IT Trends
- Cooling Design Trends
- Power Design Trends

IT Trends

- Virtualization
- Density
- Density vs Reliability Profile
- Chip Cooling

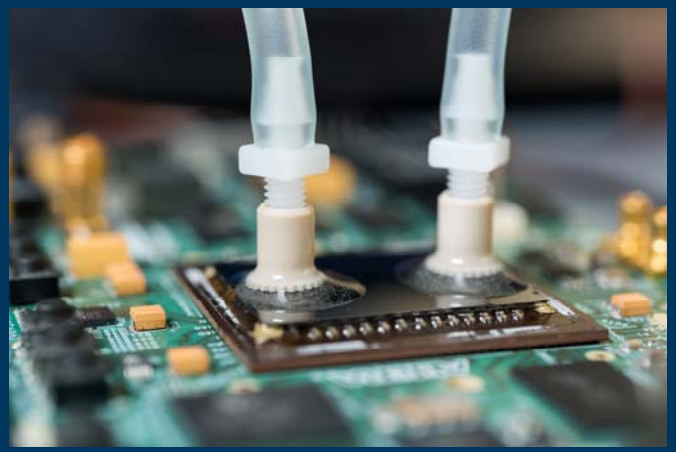
Virtualization and Density

- For every 18’F rise in temperature hardware reliability decreased by 50%
- Footprint reduction = 30% per year
- Since 2000, power consumption for chips doubled
- 17% annual increase in load density in past 10 years

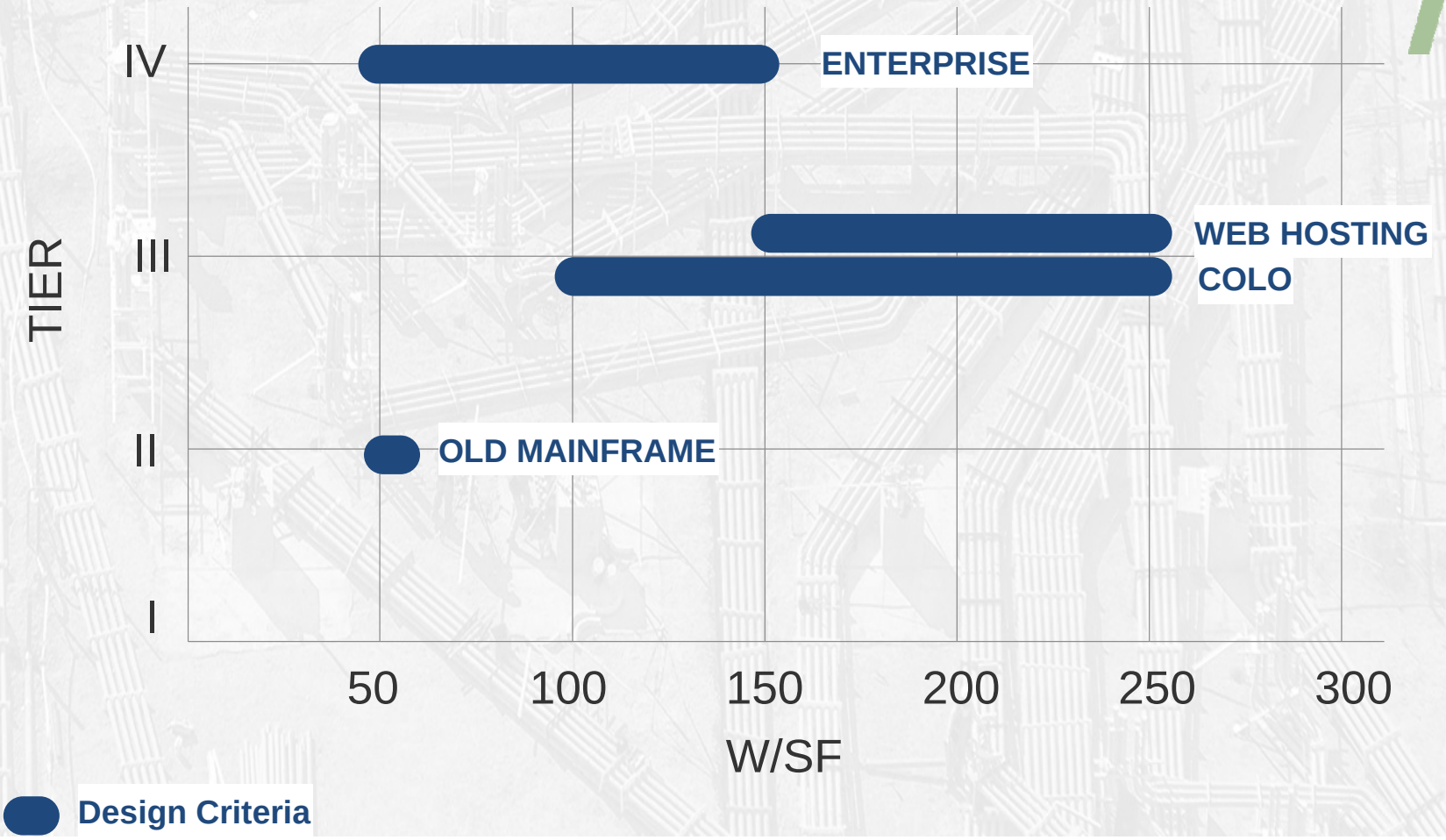
Chip Cooling

Chip Manufacturers are Investigating:

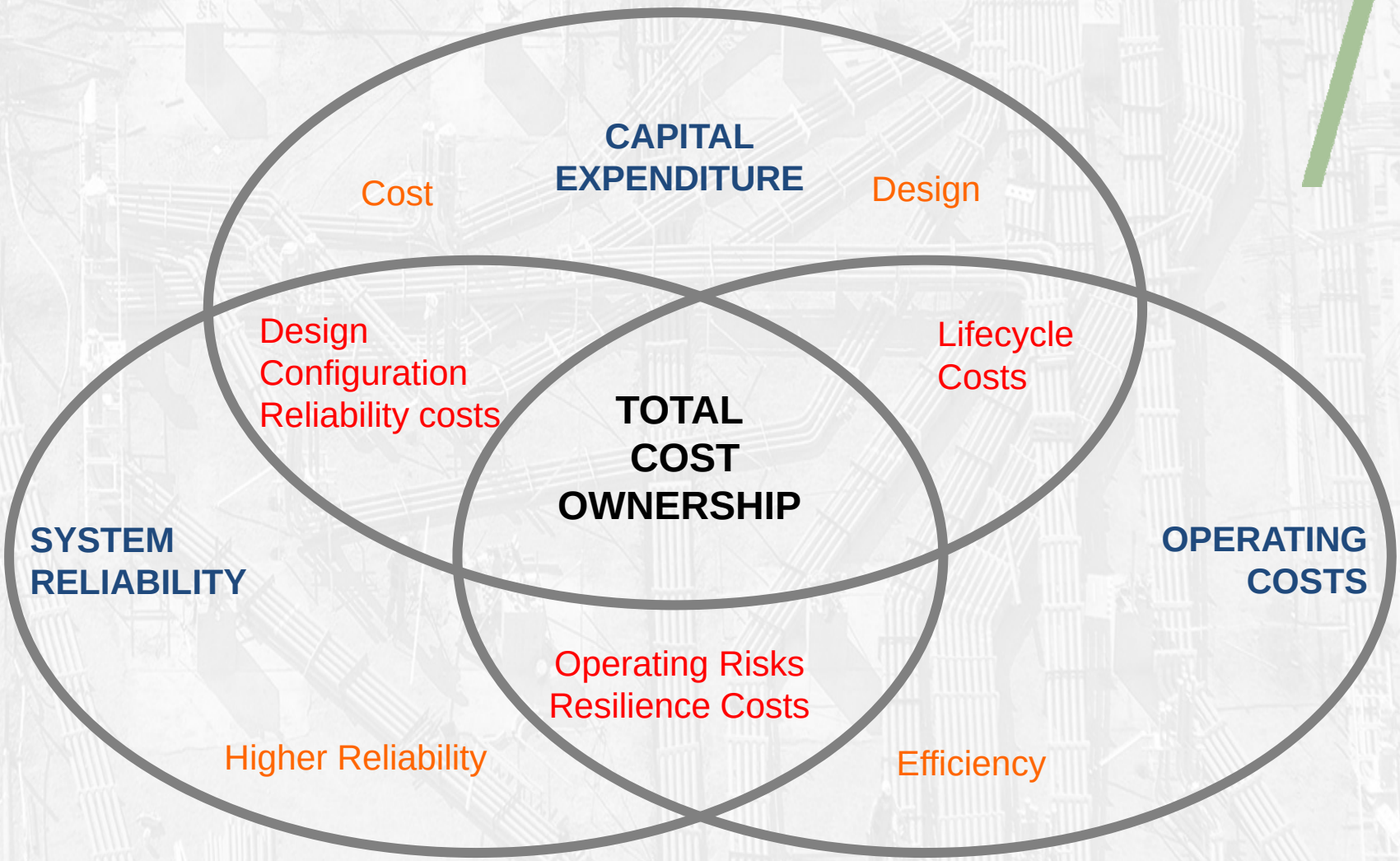
- New Sink Architectures
- Water Cooled Sinks
- Large Cooling Fans (up to 70 cfm per server)



Density vs. Reliability Profile



Total Cost of Ownership



Best Practices – Data Center Planning/Design

- Don’t lose the forest for the Tiers
- kW/cabinet is more insightful than average W/sq ft
- Nail the program, budget and schedule early on
- Design in modularity and scalability
- Optimization through planning, design and commissioning

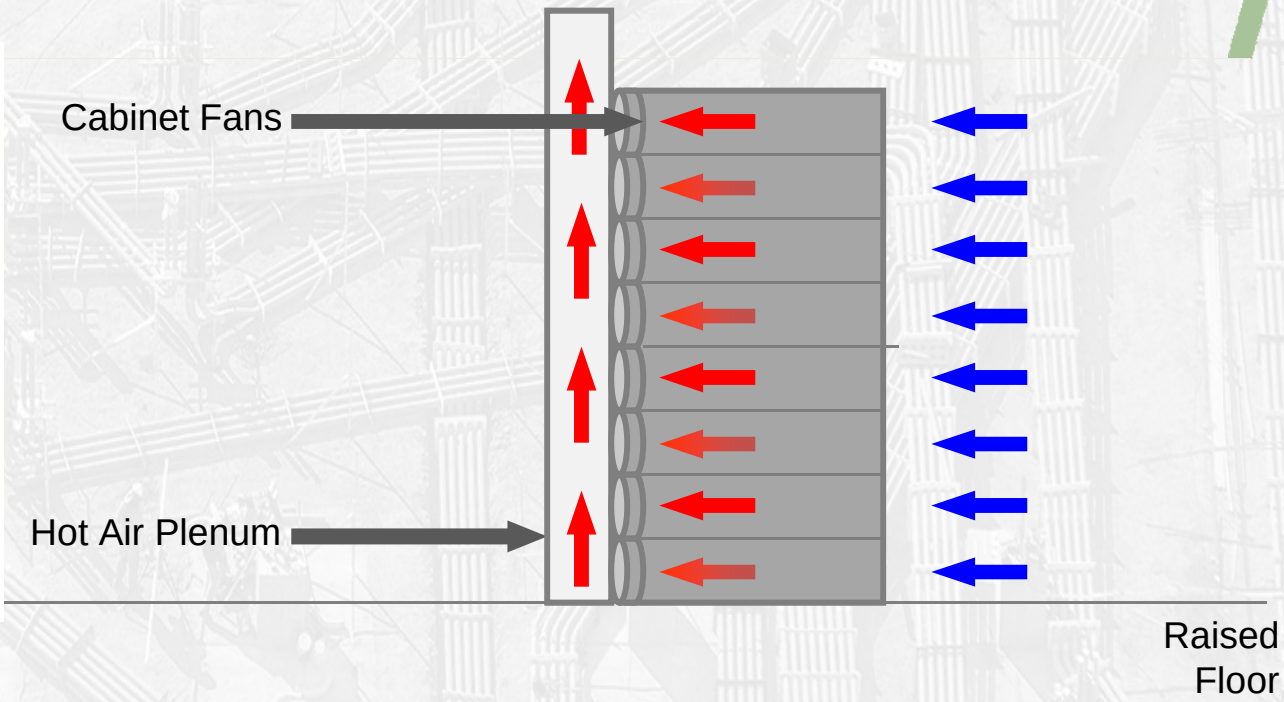
Cooling Design Trends

Fighting Density and Increasing Energy Efficiency

- In the Data Center
- For the Data Center
  - System Selection Process
  - Economization Alternatives

In The Data Center

Fan Powered Cabinet Example

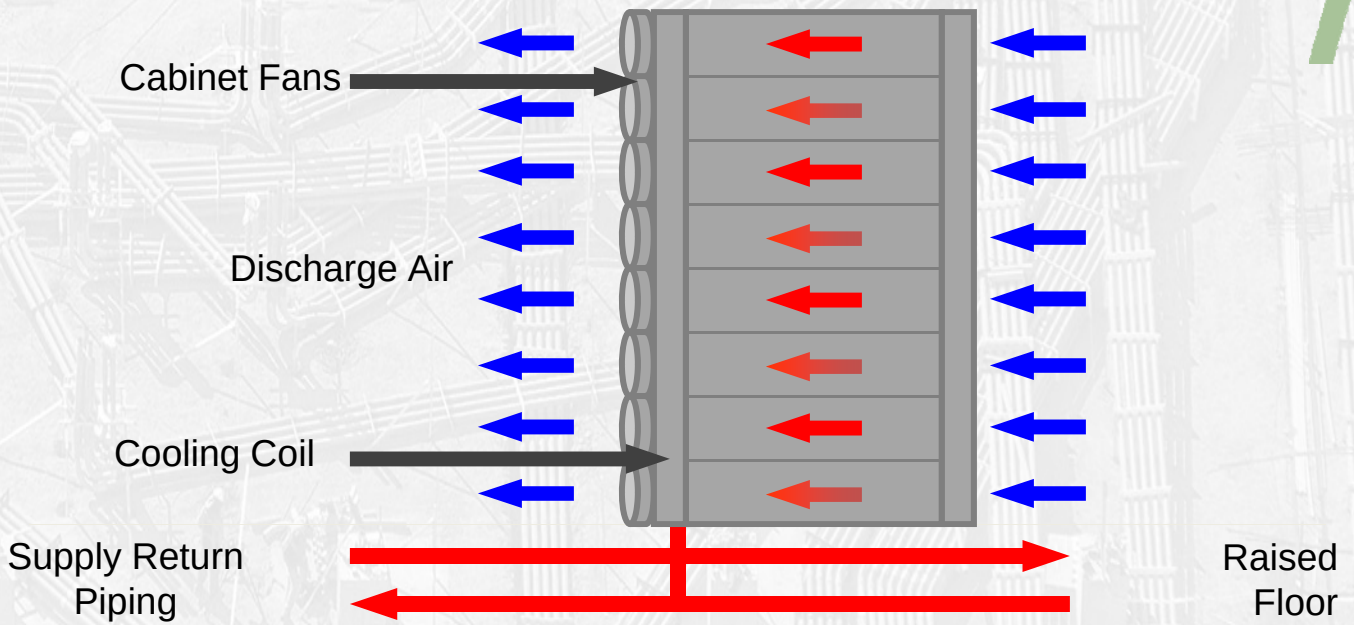


Hot Air
is discharged out of the top via ductwork

Conditioned Air
is drawn through the front of the cabinet

In The Data Center

Water Cooled Cabinet Example



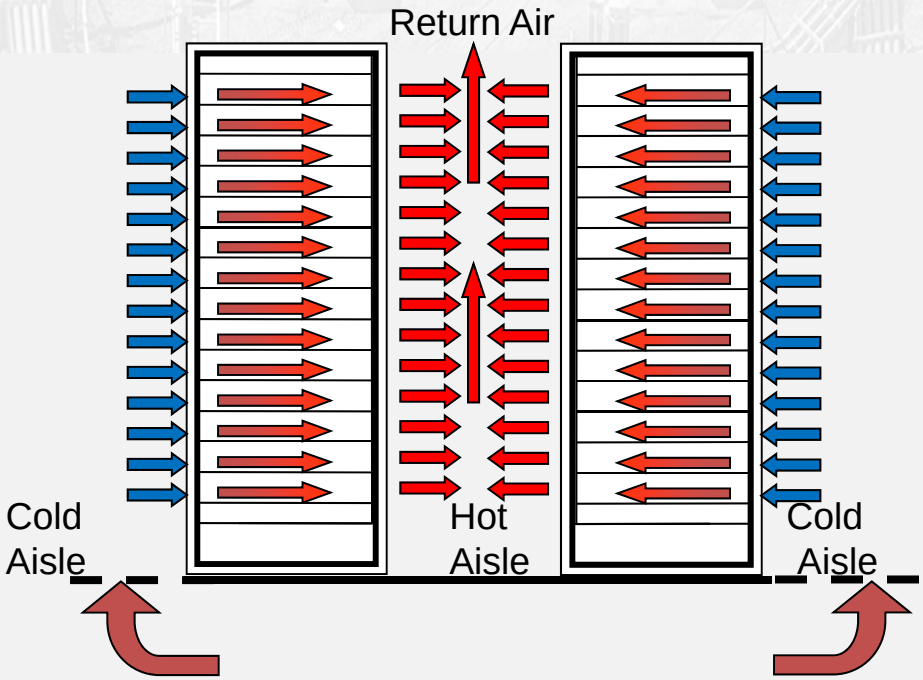
High Pressure
flex hose and quick-connect fittings to chilled water mains

Fan Coil
on rear door cools servers

Conditioned Air
is drawn through the front of the cabinet

In The Data Center

Hot Aisle Cold Aisle Configuration



Conditioned Air is drawn through the front of the cabinet

Hot Air is discharged out of the back of the cabinet

Conditioned Air is drawn through the front of the cabinet

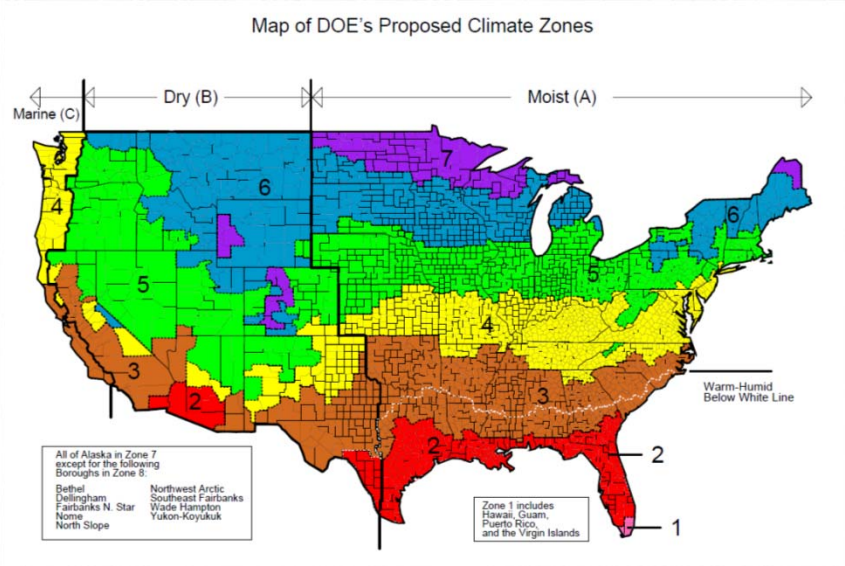
For The Data Center

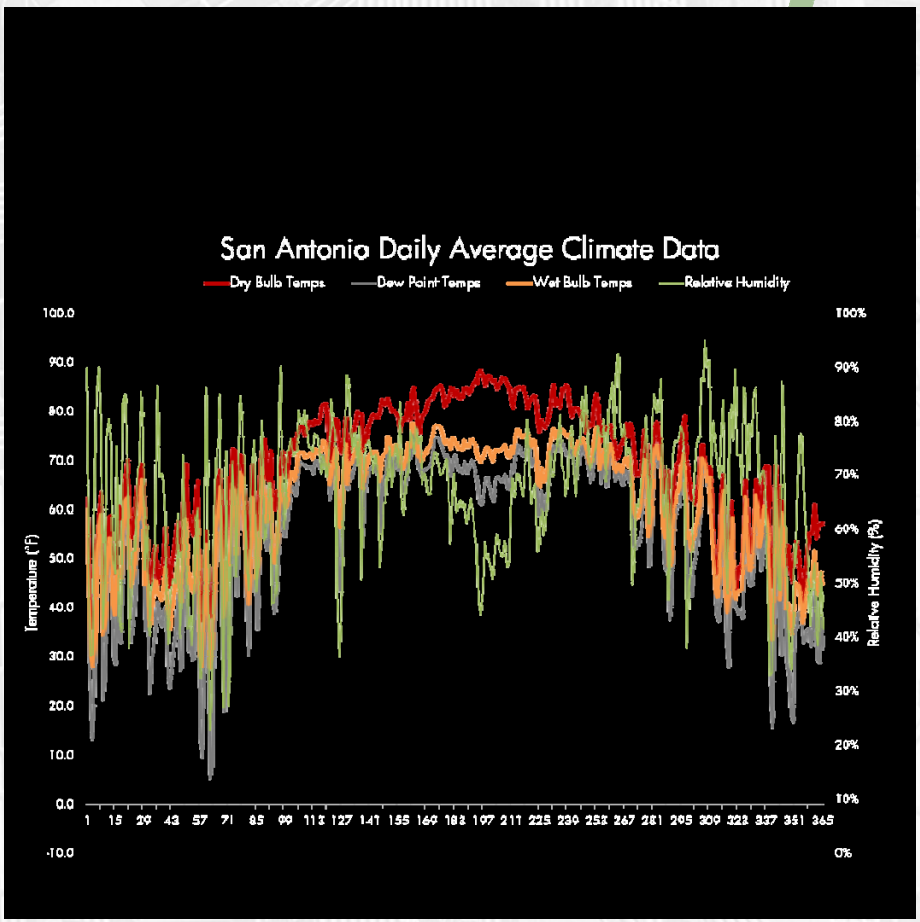
System Alternatives

- Chiller/Cooling Tower
- Air Cooled Chiller
- Adiabatic Cooling/Swamp Cooler (Roof, Ground, CRAH)
- Outside Air
- Air to Air (Munthers, Schneider, Hunt Aire, Kyoto)
- Water Side Economizer
  - (Heat Exchanger)
- DX Backup/Full-Partial
- Drycoolers

For The Data Center

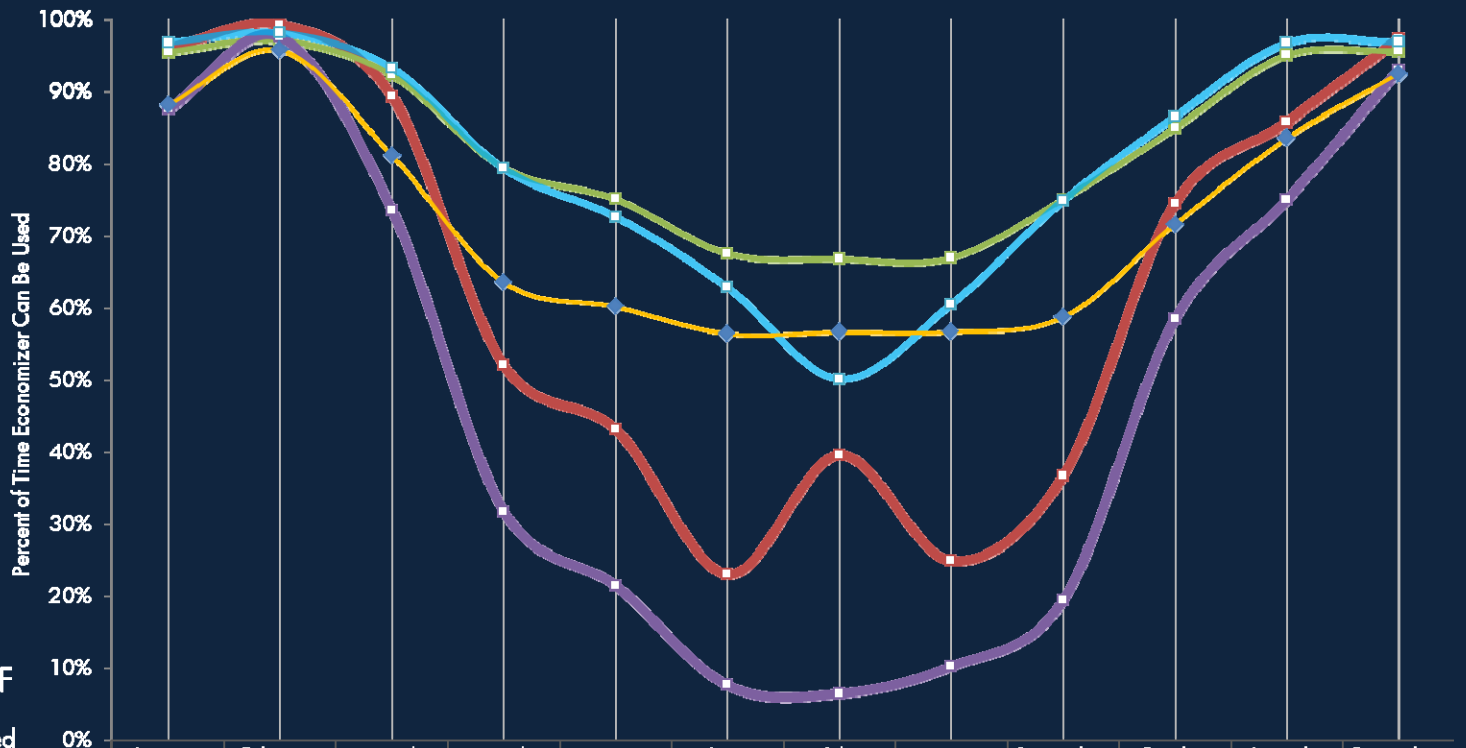
System Selection Process





For The Data Center

System Selection Process



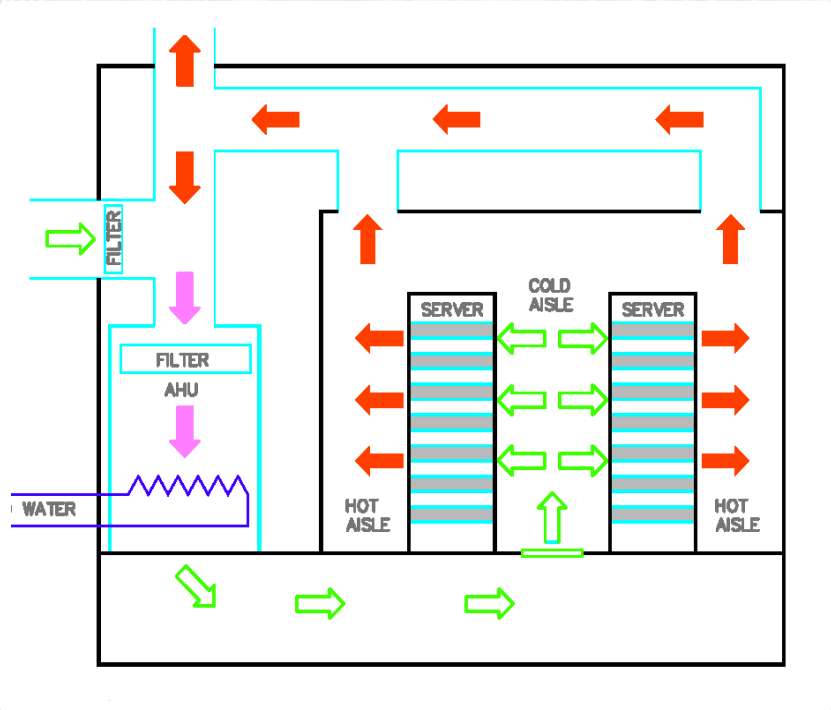
San Antonio
Supply Air Temp - 80°F
ASHRAE Class - Recommended

	January	February	March	April	May	June	July	August	September	October	November	December
Direct Evaporative	96%	99%	89%	52%	43%	23%	40%	25%	37%	75%	86%	97%
Indirect Evaporative	96%	97%	92%	80%	75%	68%	67%	67%	75%	85%	95%	96%
Direct Outdoor Air	88%	98%	74%	32%	22%	8%	6%	10%	19%	59%	75%	93%
Indirect Outdoor Air	97%	98%	93%	79%	73%	63%	50%	61%	75%	87%	97%	97%
Water Economizer Water-Cooled Chiller	88%	96%	81%	64%	60%	57%	57%	57%	59%	72%	84%	92%

For The Data Center

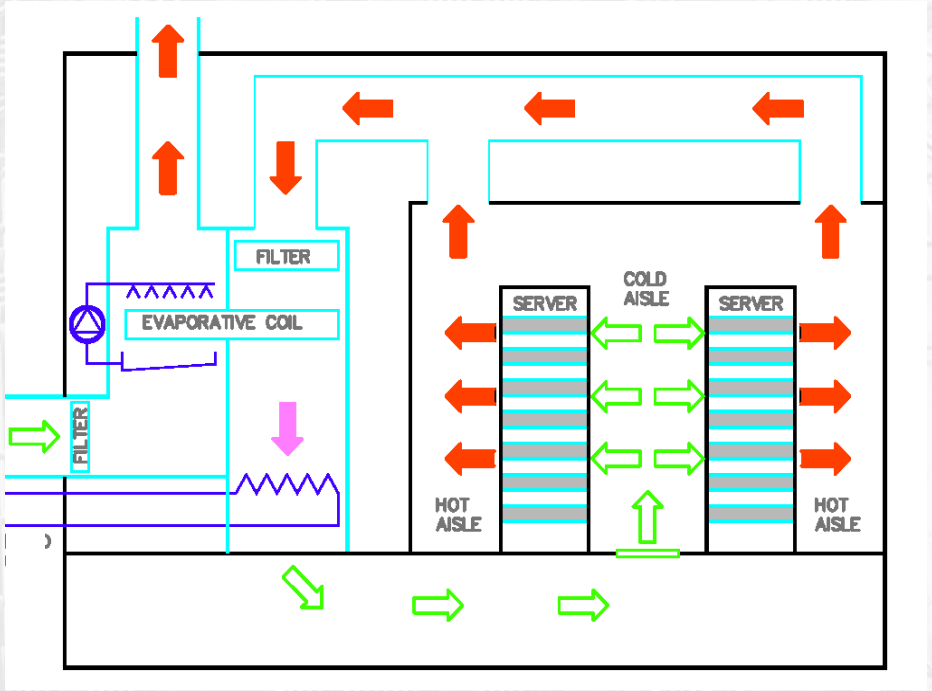
System Alternatives

Direct Air Economizer System



Outside air **does** enter the data center

Indirect Air Economizer System

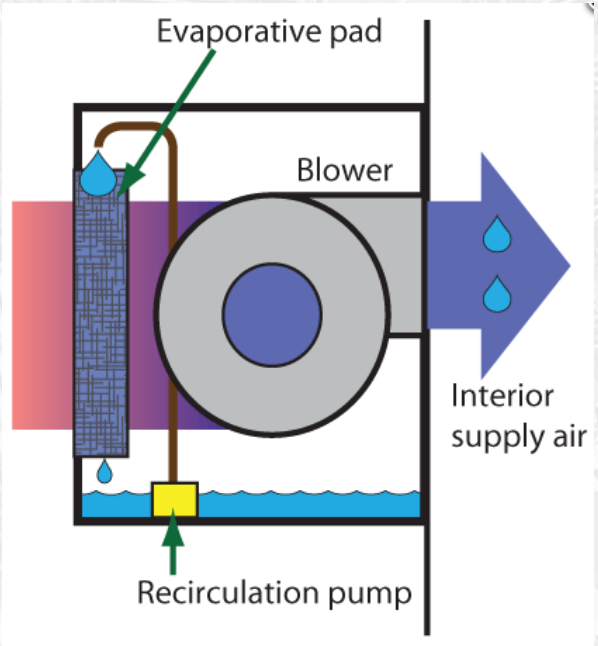


Outside air **does not** enter the data center

For The Data Center

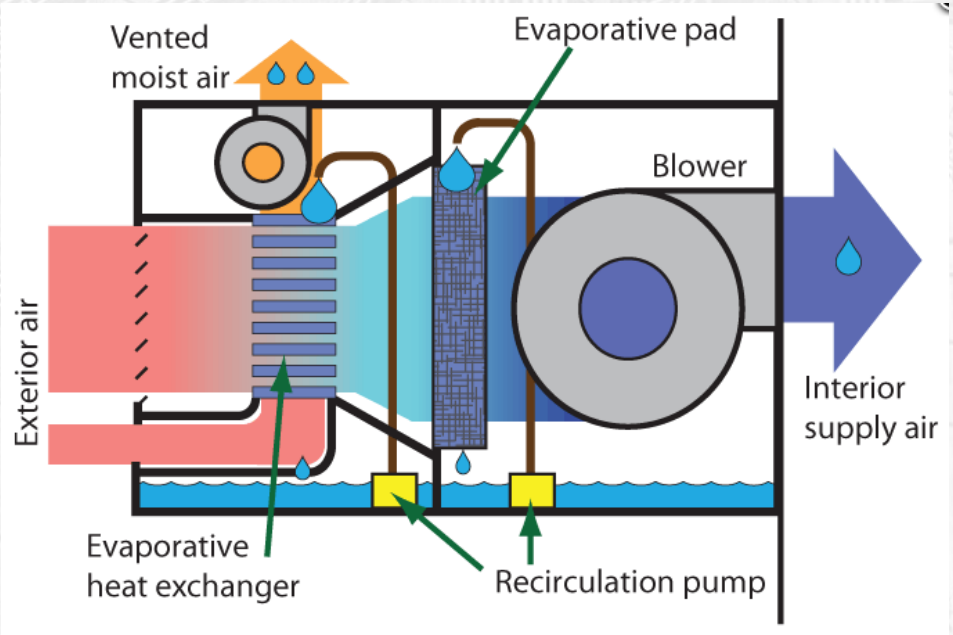
System Alternatives

Direct Evaporative Air Economizer



"Swamp" cooler **with** outside air entering the data center

Indirect Evaporative Air Economizer



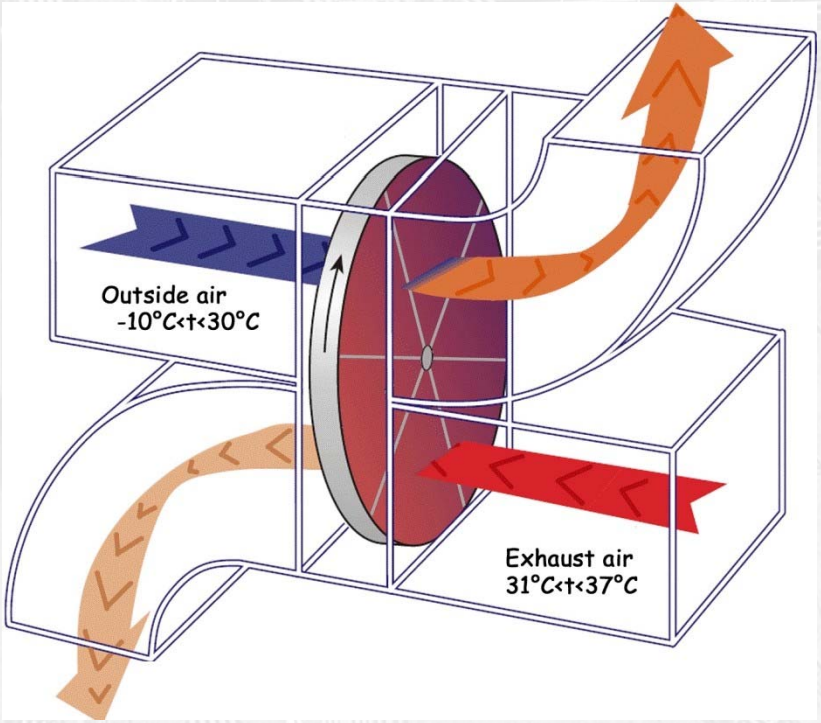
"Swamp" cooler **without** outside air entering the data center

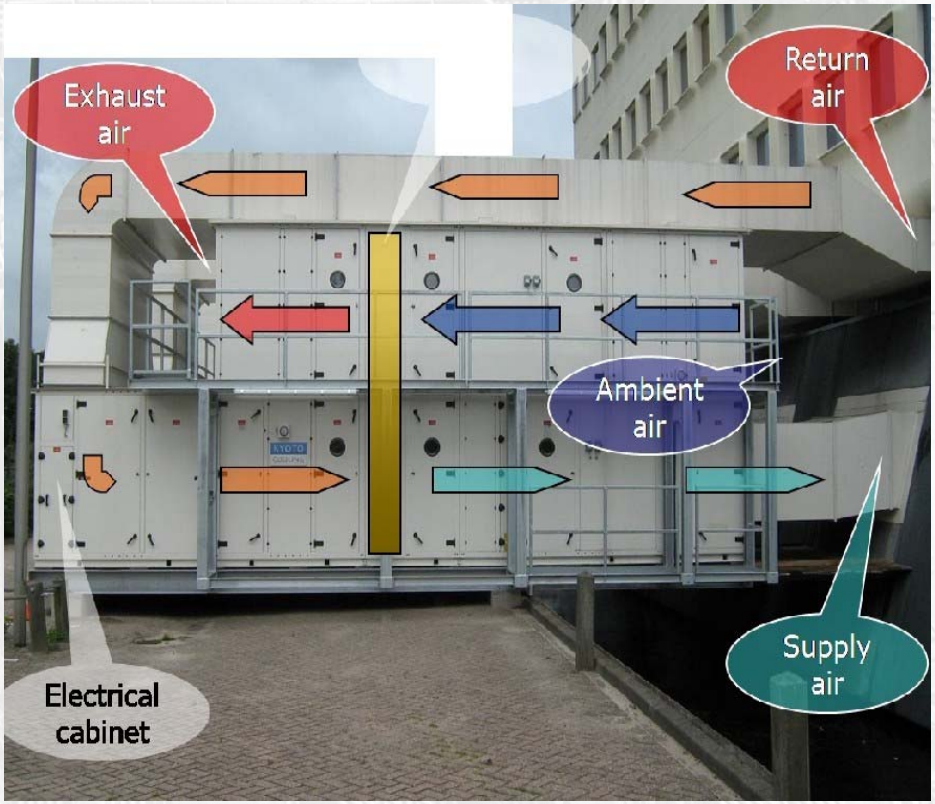
For The Data Center

System Alternatives

KYOTO WHEEL

Indirect Air-side Economizer





Power Design Trends

- Reliability / Availability
- UPS Technology
- Concurrent Maintainability
- Example One Line

MORRISON HERSHFIELD
MISSION CRITICAL

Reliability / Availability

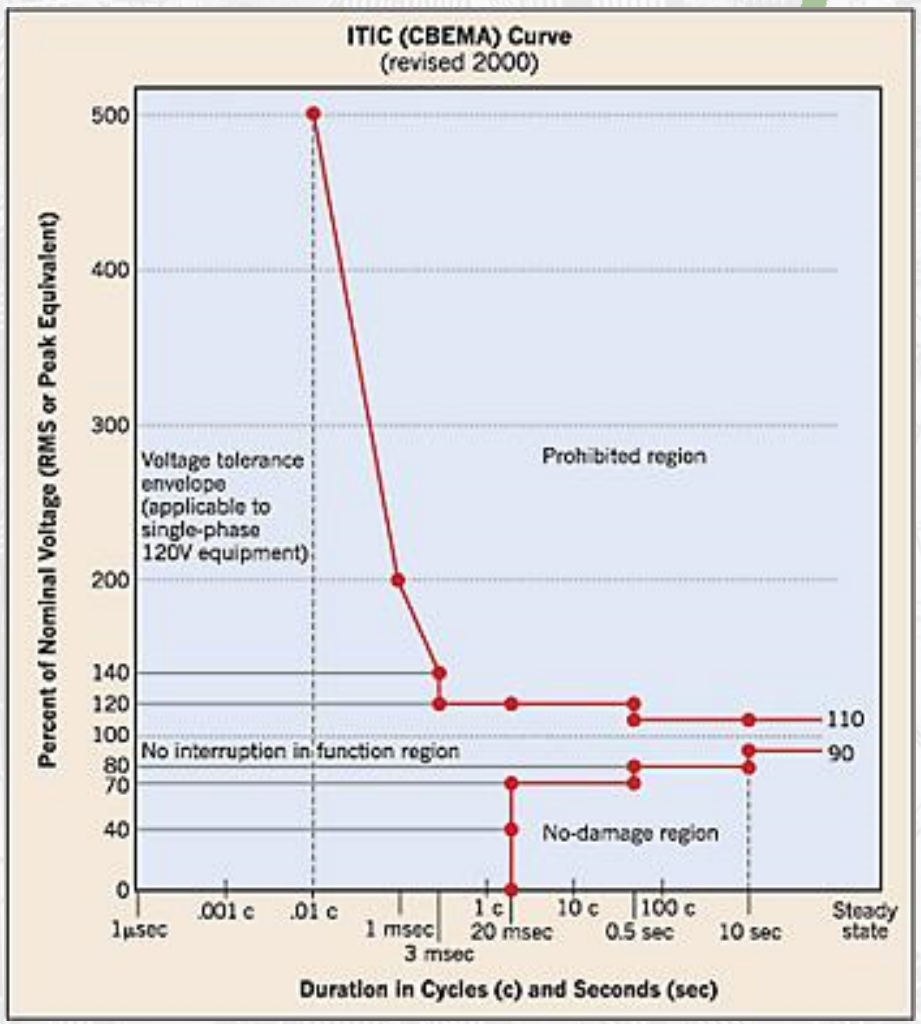
- Load Density (The Major Issue)
- 99.9999% Availability (“Six Sigma”)
- 2(N+1), 2N, N+2 Redundancy Common
- N or (N+1) Systems Not Good Enough
- Full Concurrent Maintenance
- Fault Tolerant Configurations – Eliminate SPOF’s

UPS Technology

- UPS with transformer or transformer free
  - Efficiency
  - Ground current issues
- UPS Modules with internal redundancy
  - Internal redundancy but same single input/output
- UPS System Static Switch
  - module level
  - system level
- UPS Technology
  - Double Conversion
  - Offline
  - Line interactive
  - Delta Conversion
  - Rotary
  - etc.

UPS Technology

- Eco Mode
  - Good - Efficiency
  - Bad – UPS Offline
- ITIC Curve/CBEMA Curve
- UPS Distribution Voltage
  - 600, 575, 480V, 415V, 120/208V
  - 3 Phase 3 Wire, 3 Phase 4 Wire
- DC systems and voltage – 380VDC



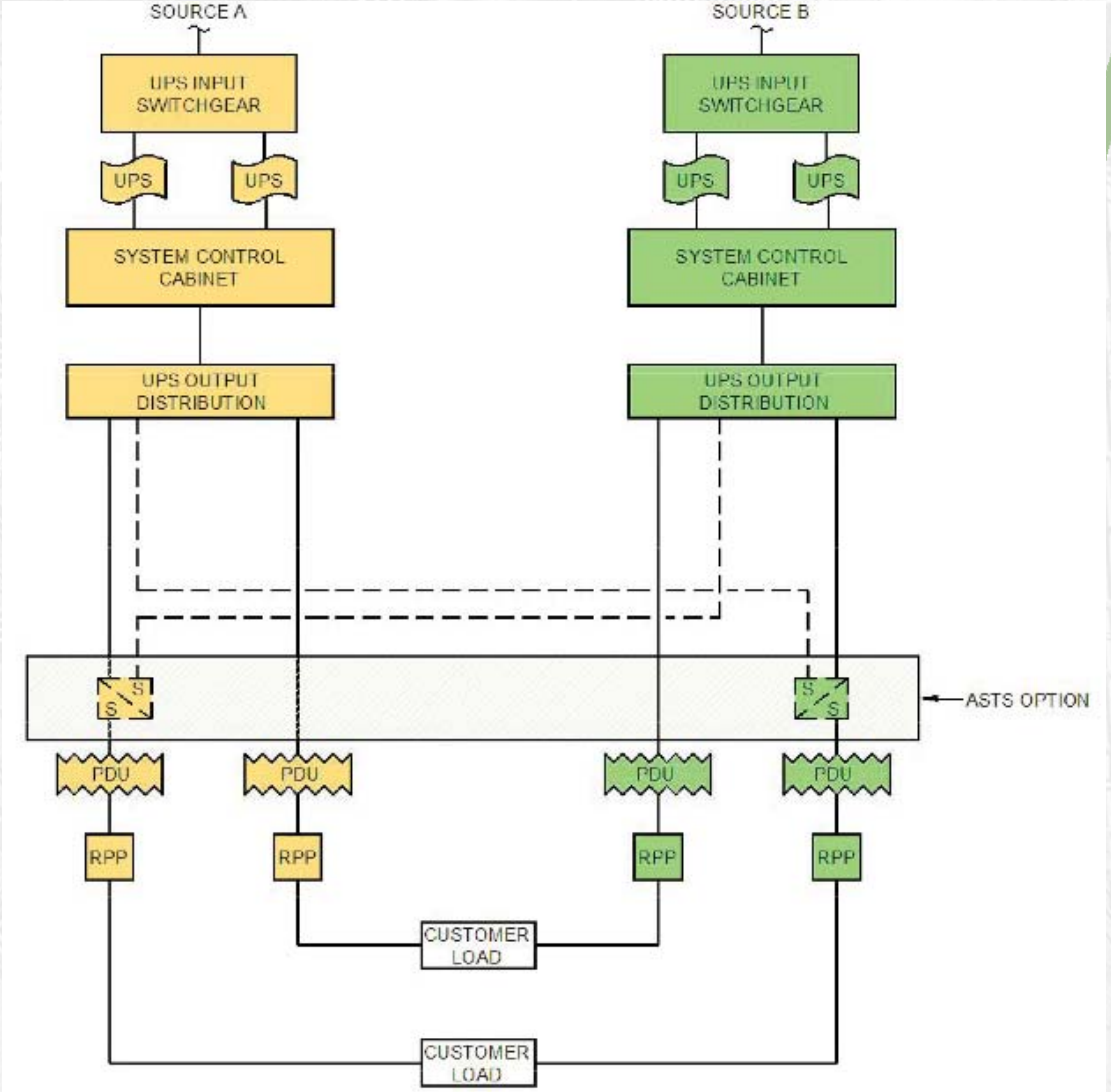
UPS Technology

Typical UPS Configurations

- Single Module Systems
- Isolated Redundant
- Parallel Redundant
- Distributed Redundant
- Block Redundant

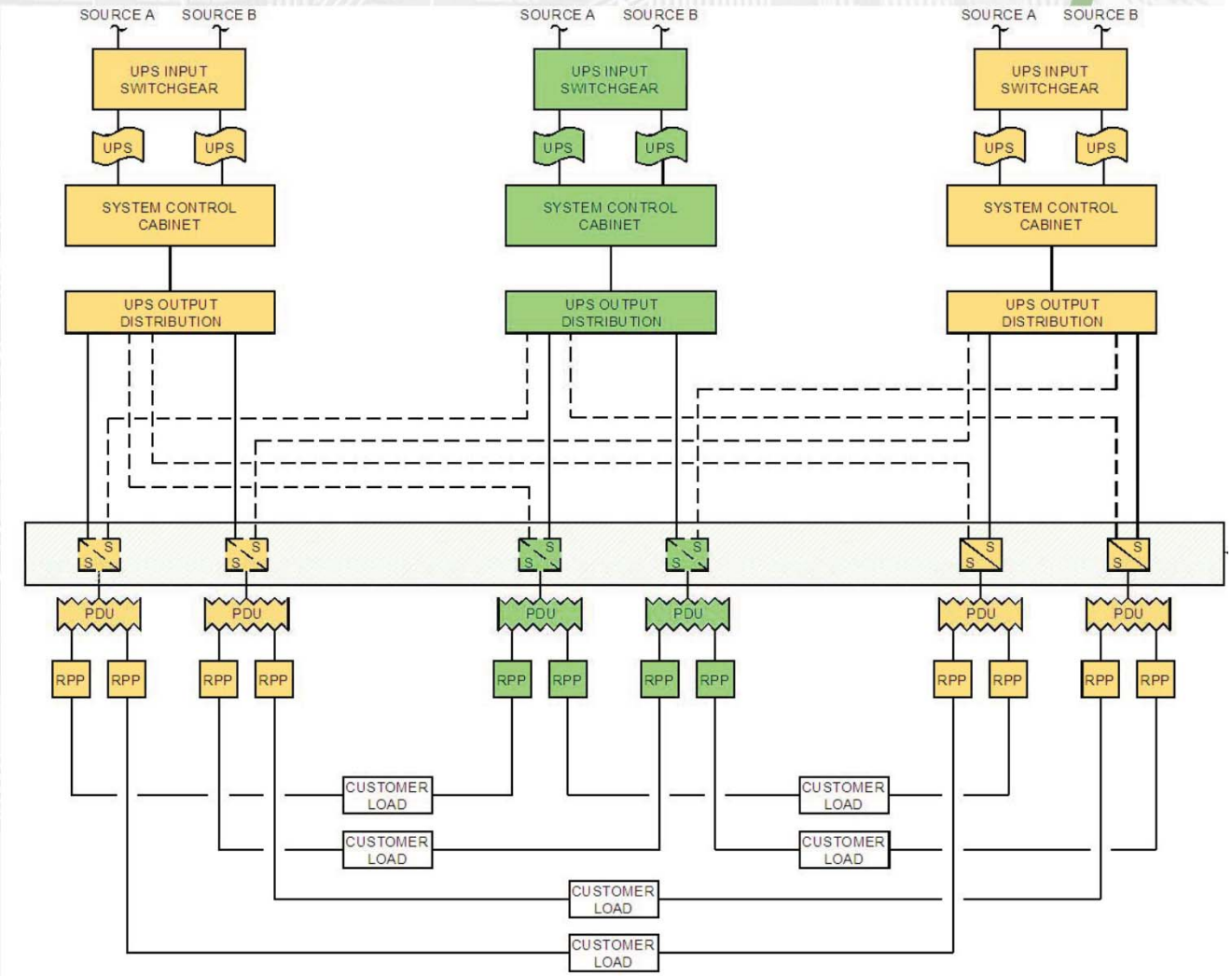
Reliability / Availability

Parallel Redundant



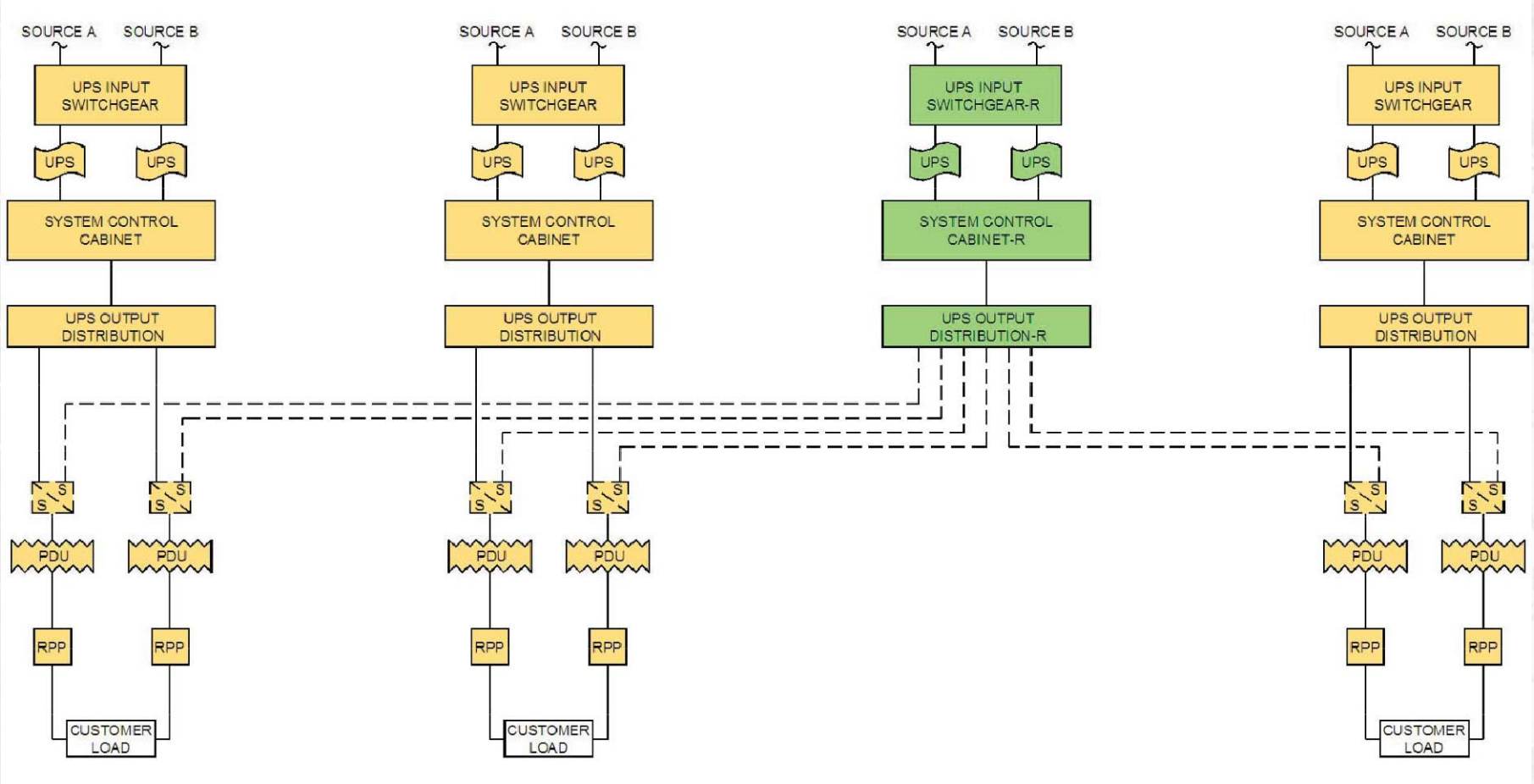
Reliability / Availability

Distributed Redundant



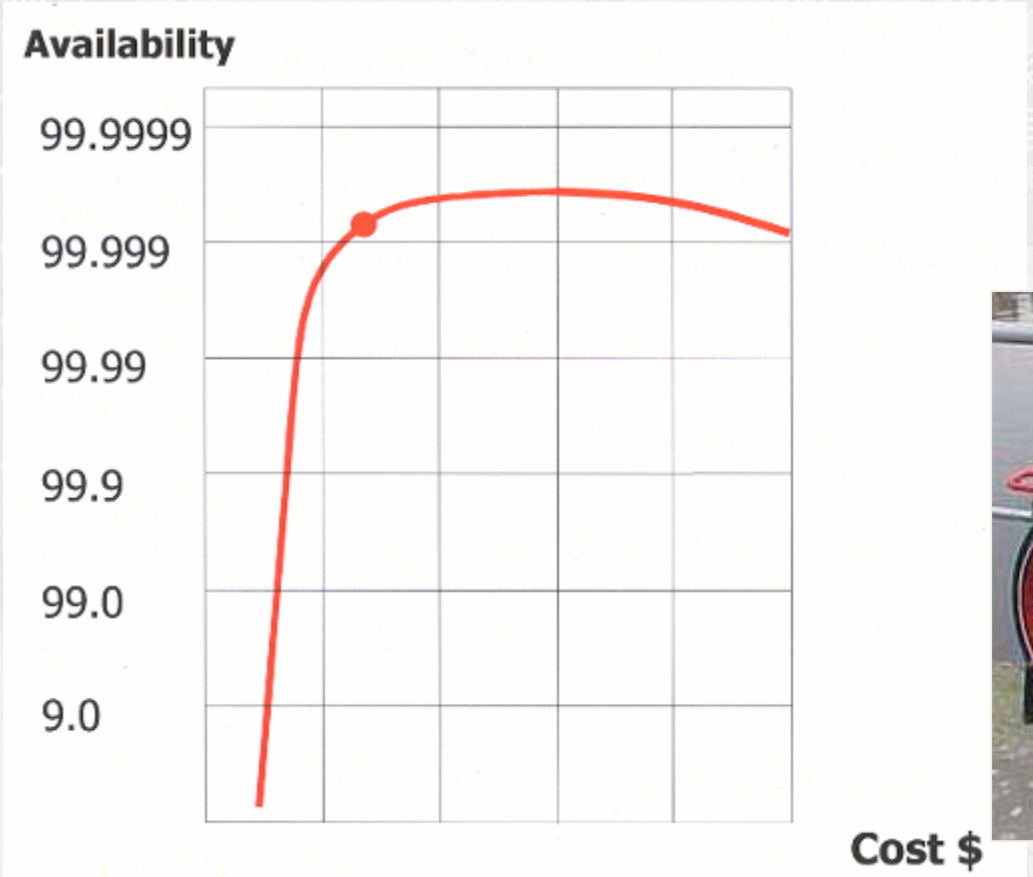
Reliability / Availability

Block Redundant



Cost, Availability and Design Topology

Pushing the Limits of Complexity = Bad Capital Investment



Data Center Electrical Infrastructure

Topologies – Reliability Table

Description of RBD	MTBF (Hours)	Inherent Availability (A_i)	Probability of Failure in 5 years
N + 1 UPS system - dual cord loads	32,509	0.99981626	58.16%
Distributed Redundant (2-3) UPS system - dual cord loads	161,646	0.99997994	7.43%
2N UPS system - dual cord loads	214,182	0.99998723	6.56%
2(N + 1) UPS system - dual cord loads	305,251	0.9999868	6.49%
Utility and N + 1 UPS system, ASTSs - dual cord loads	65,056	0.99999821	8.02%
Redundant Reserve (2-3) UPS System, ASTSs - dual cord loads	257,459	0.99999058	2.58%
Distributed Redundant (2-3) UPS system, ASTSs - dual cord loads	256,674	0.99999046	2.72%
2N UPS system, ASTSs - dual cord loads	445,691	0.99999845	1.12%
2(N + 1) UPS system, ASTSs - dual cord loads	989,960	0.99999839	0.88%

Electrical Trends

575V Distribution

Traditional voltage distribution to the PDU primary is 480V, consider use of 575V

Benefits:

- Reduces cable and bus sizes by 20%
- Allows systems to operate more efficiently
- Allows more capacity out of the equivalent 480V infrastructure
- Maintains the use of standard equipment sizes
- Can be utilized with UPS, motor and all other major equipment within the building
- Overall reduces initial installation cost and long term maintenance and operating costs

Electrical Trends

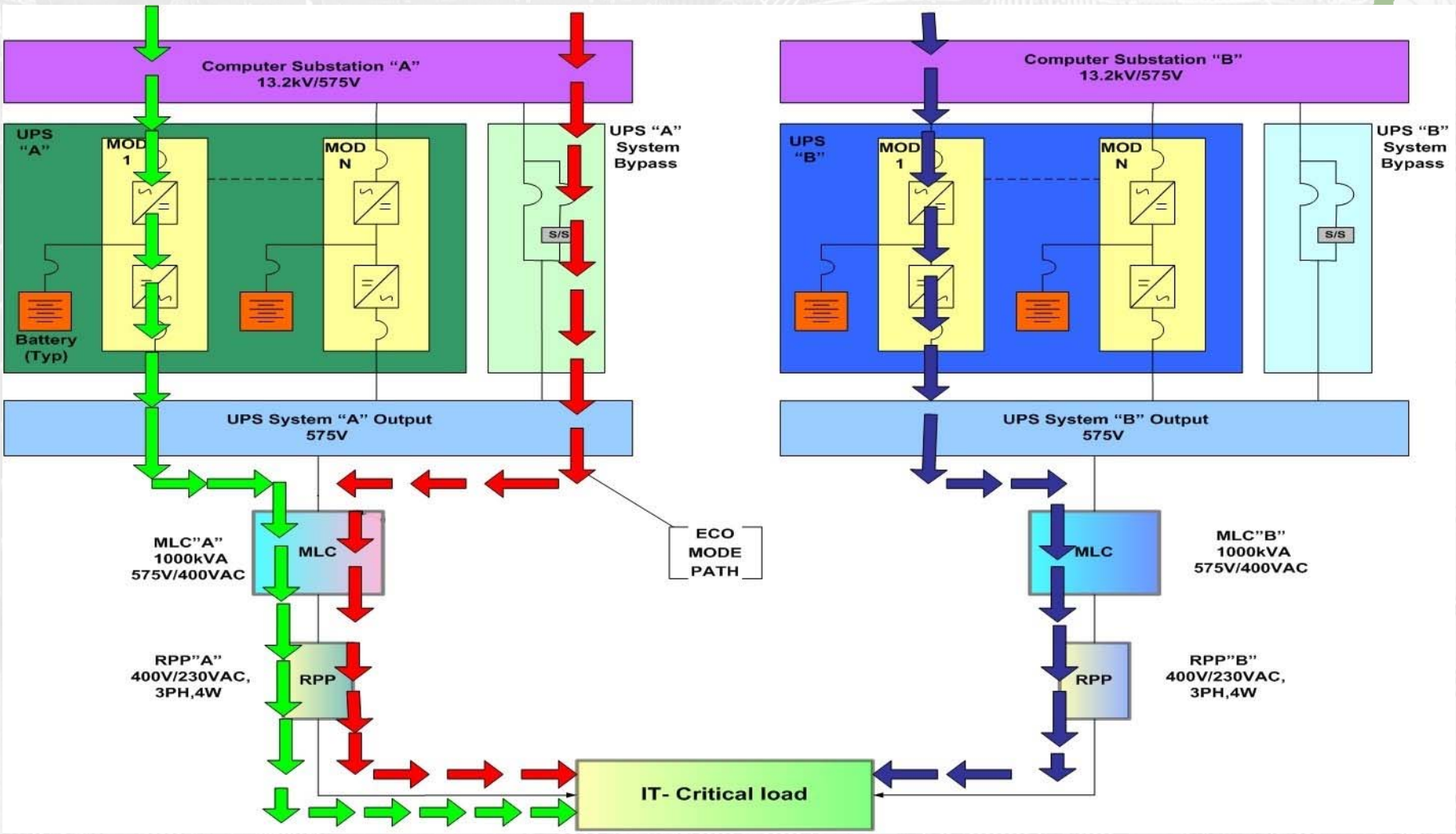
415V Distribution and Eliminate Transformers

- Transformers are traditionally used to step down the voltage to 208V for use at the server rack.
- Because the vast majority of modern servers are designed for the global market including the IEC low voltage standard 415/240V, the implementation of a 415/240V UPS system with a 3 phase, four wire distribution can be used.
- Distribution at 415/240V eliminates the transformation requirements and aligns critical loads directly with the UPS

Benefits:

- Still maintains the use of standard equipment, electrically and servers
- Reduces one level of transformation, increasing overall electrical efficiency by ~2%.
- Reduces HVAC requirements by 6 tons/MW.
- Reduces the amount of equipment needed to support the load, reducing initial costs.
- Increases reliability and availability, and reduces maintenance costs

Electrical Trends – Eco Mode



Concurrent Maintainability

Goals

- "Change Tires, Transmission and Engine at 60mph…and Don't Lose Speed."
- No IT Downtime for Preventative and Corrective Maintenance
- Scalability

Concurrent Maintainability

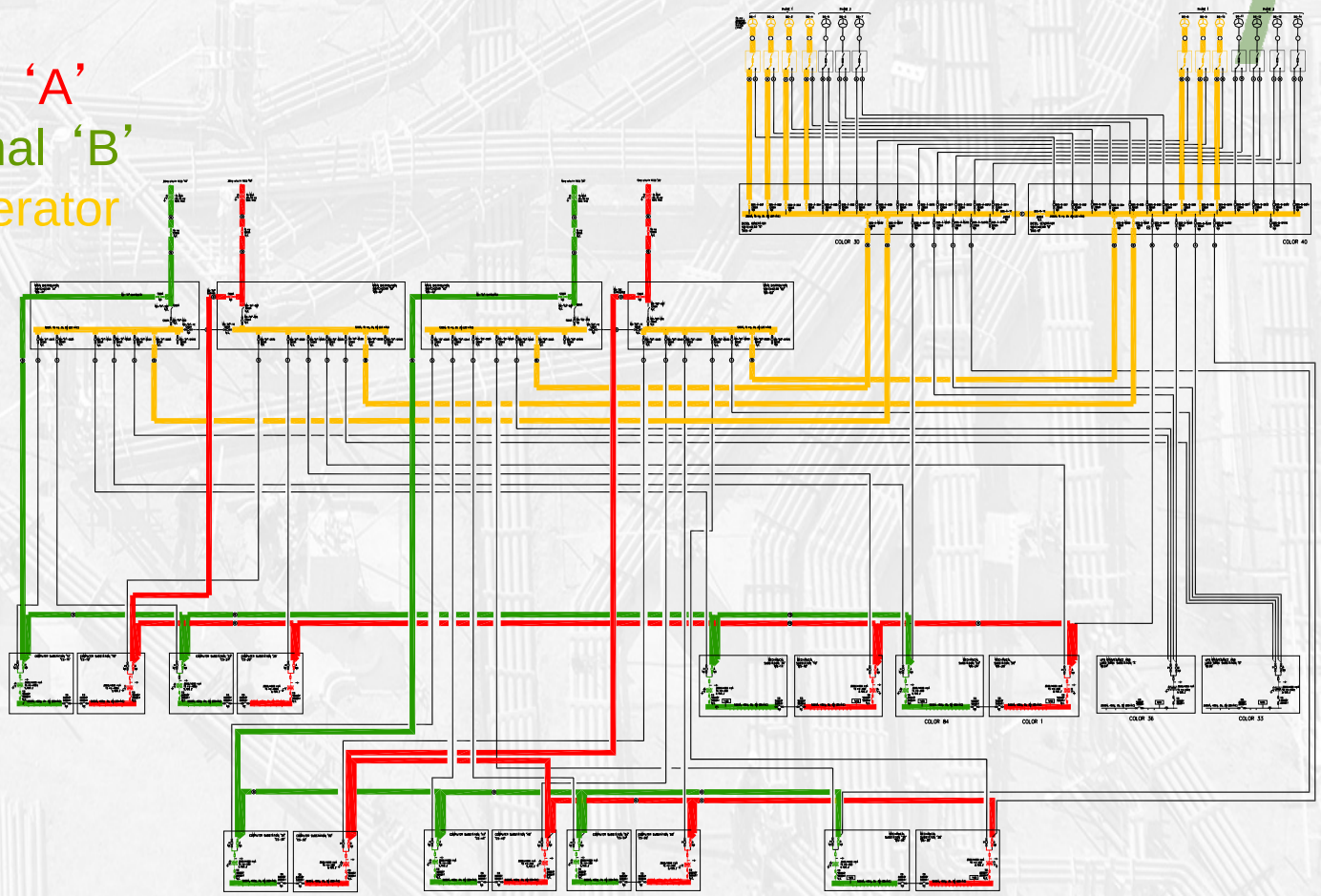
The Solution

- Dual/Diverse Utility Services
- Dual Active Distribution Paths
- N+2 Generator Plant
- “Self-Healing” Automation and Control
- Physical Separation/Compartmentalization
- 2N Static UPS or Similar
- Dual Electrical Cords to IT Cabinets

Medium Voltage Distribution

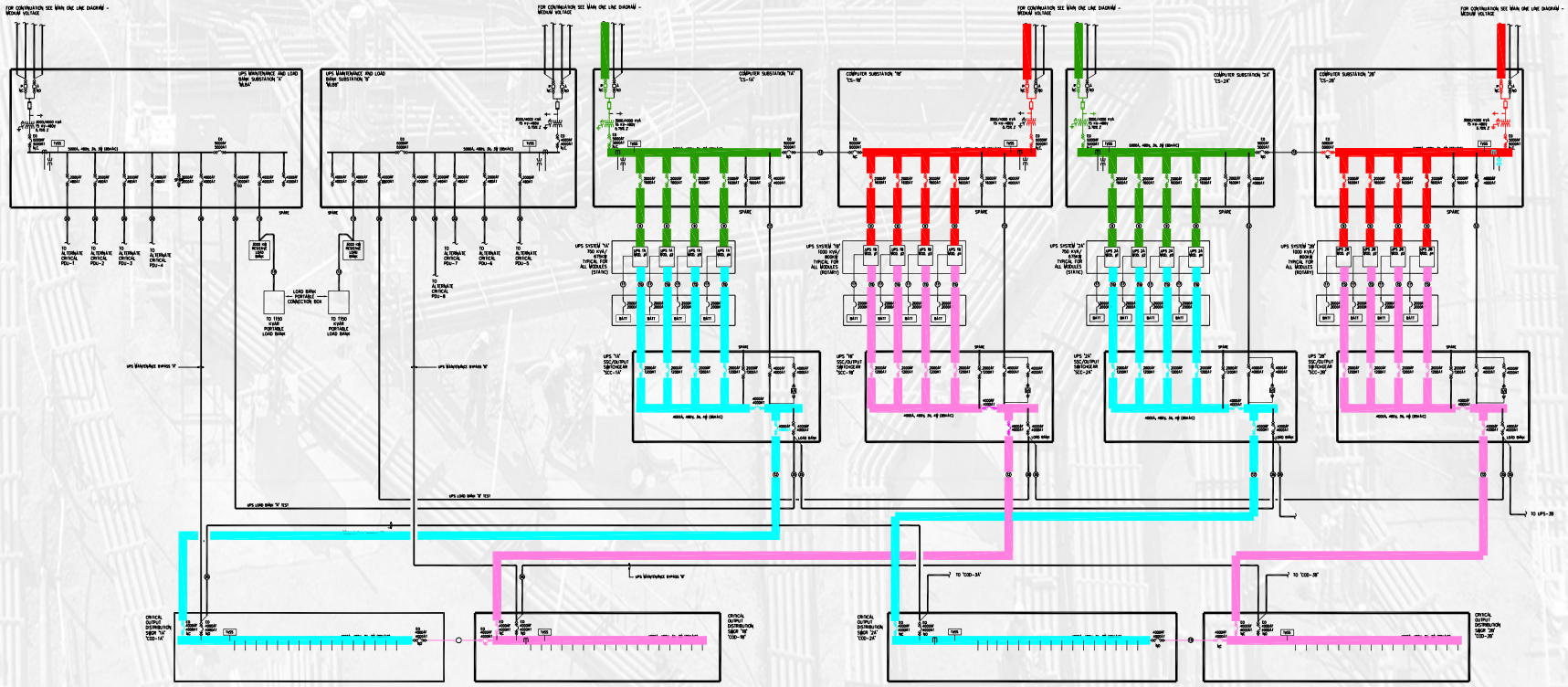
Utility Bypass/Gen Control Maintenance

Red-Normal ‘A’
Green-Normal ‘B’
Yellow-Generator

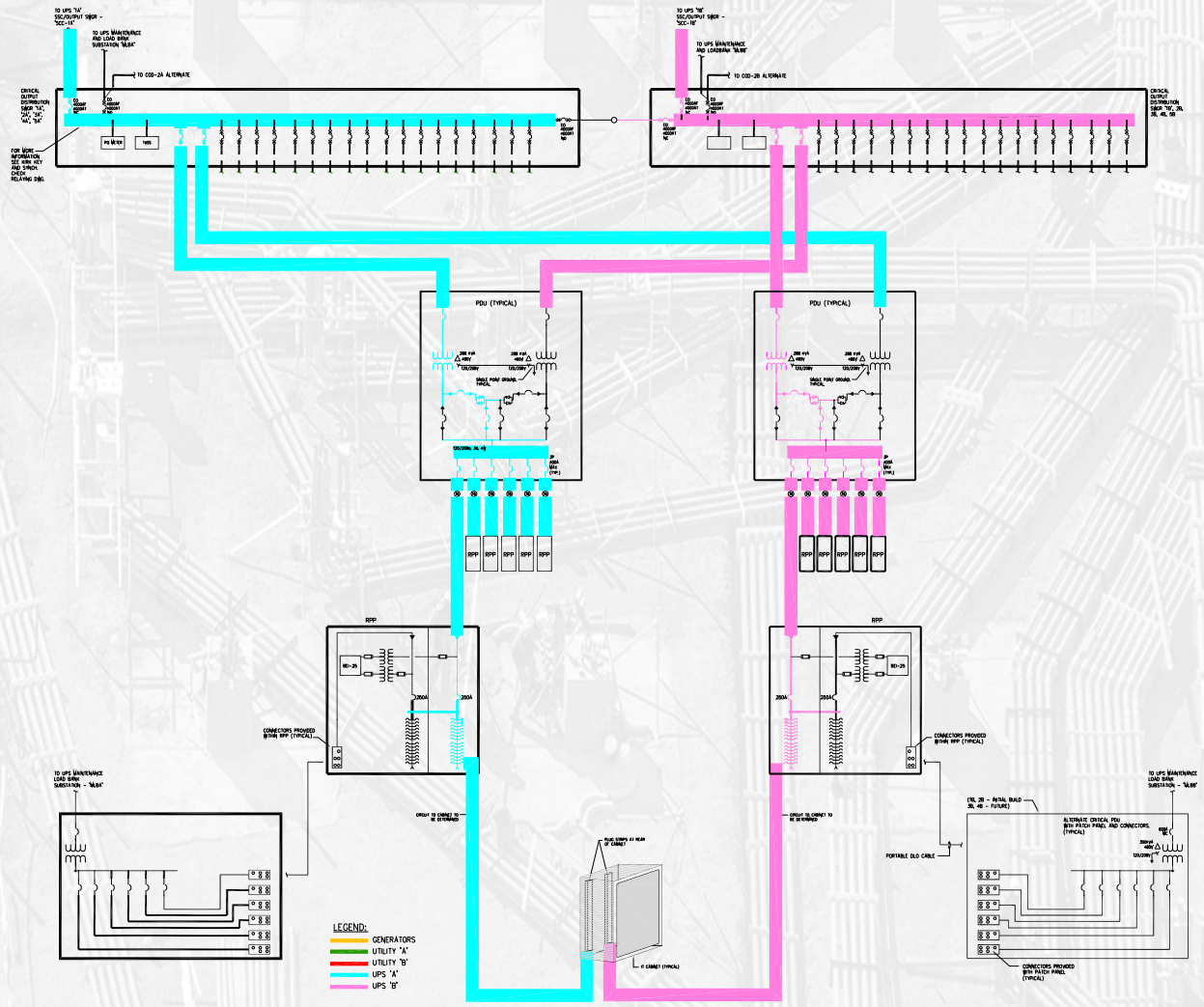


UPS – Normal Operation

Red-Normal ‘A’
Green-Normal ‘B’
Blue-UPS ‘A’
Pink-UPS’ B’



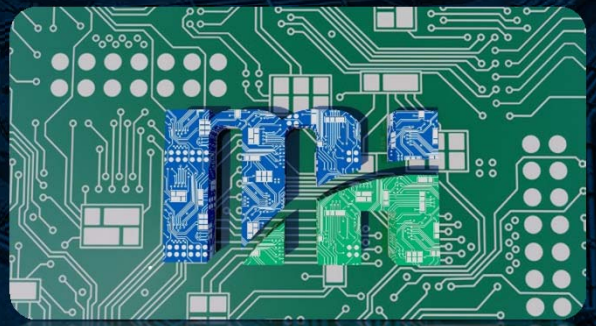
UPS to RPP Normal Operation



Blue-UPS 'A'
Pink-UPS' B'

QUESTIONS?

Thank you and please feel free to contact me



Steven Shapiro, P.E.

SShapiro@MorrisonHershfield.com

linkedin.com/in/stevenshapirope

IEEE

MORRISON HERSHFIELD
MISSION CRITICAL