BRUNS-PAK Presents
MARK S. EVANKO, Principal

"Data Centers Development for the Short & Long Term"

NFM&T

Conference/Expo

Baltimore Convention Center

Tuesday, March 16, 2010 – 10:00am – Room 347

Agenda

I	Overview
II	Data Center Green Initiatives
III	Reliability vs. Redundancy vs. Uptime – “The Data Center Green Initiatives” – are they Compatible?
IV	The Role of “LEED”
V	Data Center Cost Impacts and Trends
VI	Sample CFD Slides
VII	Questions and Answers

Part I

Overview

Overview

Experience:

1. More than 30 years designing, engineering, and constructing advanced computing and technology facilities.
2. Participated in over 4500 data center projects in Industrial, Healthcare, Retail, Higher Education, Pharmaceutical, Public Sector, Banking, Insurance, Financial, Government, IT Consulting, and Publishing Industries with a significant repeat customer base.
3. Full-service staff of licensed civil, electrical, mechanical engineers, and architects as well as construction project managers, systems specialists, CADD technicians, commissioning agents, CFD/IT architects, and other skilled professionals.
4. We provide national based discussions regarding our experience in developing "ultra-reliable" data/telecommunication centers at well established conferences such as:

AFCOM	Server Blade Summit	NFM&T
7 X 24	IBM Data Centers Conference	SHARE
Data Center Dynamics	IBM IPR Conference	Uptime Institute
Ethernet Conference		

5. We have extensive experience in developing phased expansion of higher education, corporate, and public sector data center facilities and designing and building new data center facilities.

First Data Corp.
Darden Restaurants
Catholic Health Services of Long Island
Northeast Utilities System
University of Rochester
Campus Crusade for Christ
GE Healthcare Technologies
University of Maryland 1856
CVS
Harvard University Division of Continuing Education
medcohealth live life well
Pfizer
Key Services Corporation
Catawba Valley Medical Center
Yale University
Community Health Network
Edward Jones
National Grid
Liberty Mutual
Johnson & Johnson
Kodak
Dartmouth founded 1769
Wyeth
The Coca-Cola Company
Pepsi Americas

Strategic Alliances

at&t Consulting

Deloitte
(Collaborations)

cisco

EMC²
where information lives

DMJM H&N | AECOM

IBM®

GLOBALSOURCING
ADVISORY GROUP

accenture

SUNGARD®

Media Recovery
Supplies, Services & Solutions

Alcatel·Lucent

Gartner

SIRIUS
COMPUTER SOLUTIONS

Mainline
INFORMATION SYSTEMS

Collective
Technologies

Part II

Data Center Green Initiatives

Data Center Green Initiatives

- The primary focus of the data center Green initiatives is a focus on reducing energy costs
- The mix of the contributing data center components contributing to energy consumption:

  A. Computer Hardware

  B. Computer Software

  C. Telecommunications (Data/Tele)

  D. Facility Infrastructure

- Data centers are estimated to account for between 1.4 and 2% of the electricity consumed in the United States

Data Center Green Initiatives

- Past historical trends of server utilization have ranged from 10% to 15% - inefficient
- Past historical data centers were tremendously inefficient from a comprehensive power consumption standpoint
  A. Electrical/Mechanical Infrastructure
  B. Server Technology
  C. Monitoring Systems
- Department of Energy is now in motion on data centers – efficiency, efficiency, efficiency!

Data Center Green Initiatives

- The impact of cloud computing on data center energy efficiency
  A. Real deployment. Apple, IBM, EMC, HP, Dell
  B. HAAS – Hardware as a Service
  C. SAAS – Software as a Service
  D. Cloud computing "both individuals and enterprises can access a large range of software online and only pay for what they use when they use it".

Data Center Green Initiatives

E. Client receptiveness – those who might have “peak” intermittent computing demands during the year.

F. What is the impact to data center facility infrastructure planning, efficiency, and modularity?

Data Center Green Initiatives

- Past data center electrical/mechanical observations – for every watt of IT power (computer) an additional watt is used to cool and distribute power to IT equipment
- Watts/hour are a utility cost charge
- Overview:

A. Data centers older ~ 20-45 watts per sq. ft.

B. Data centers today can exceed 1,500/2,500 watts per sq. ft. in isolated areas

- Data Center summary energy efficiency metric

Data Center Green Initiatives

- Q = CIA

  NOT

  Y = MCA??

  Q = CFM

  C = Coefficient

  I = Velocity

  A = Area

Data Center Green Initiatives

Power Usage Effectiveness (PUE) Metric

PUE puts a focus on maximizing the power devoted to the equipment running applications and minimizing the power consumed by support functions like cooling and power distributions. PUE is defined as the ratio of the total power consumed by a data center to the power consumed by the IT equipment that populate the facility.

Data Center Green Initiatives

$$\text{PUE} = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

$$\text{DCIE} = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}} \quad \text{- Inverse}$$

Scenario	PUE
Current Trends	1.9
Improved Operations	1.7
Best Practices ?	1.3
State-of-the-Art ?	1.2
Impact of PUE with:	- Mirrored data centers (see State of the Art) - Redundancy/elimination single point of failure - Cloud computing

Data Center Green Initiatives

The Carbon Footprint Reduction – Correlating Initiative

Minimizing the Carbon (CO_2) Footprint:

- Recycle
- Print Both Sides of Paper
- E-Papers
- Email
- Power Efficiency
- Cooling Efficiency

Data Center Green Initiatives

- By reducing data center energy costs via “Green efficiency initiatives”, the owner reduces operating costs and keeps their business competitive. In addition, the environment benefits significantly from reduced “carbon production”.
- GOOGLE’S Five Step Plan:
  - Minimize electricity used by servers
  - Reduce the energy used by the data center facilities themselves
  - Conserve precious fresh water by using recycled water instead

Data Center Green Initiatives

- GOOGLE’S Five Step Plan (con’t):
  - Reuse or recycle all electronic equipment that leaves our data centers
  - Engage with our peers to advance smarter energy practices.
- Annual savings per server:
  A. Electricity – 500 kWh saved
  B. Carbon Dioxide – 300 kg saved
  C. Water – 1,000 gallon saved

$30 saved per server per year!

Data Center Green Initiatives

- The role of delivering precise, temperature regulated, airflow to computing equipment – thermodynamics and models
- Data center best practice considerations:

A. Buy efficient computing equipment – virtualize existing multiple sever applications

B. Optimize the air flow and distribution within the computer room to the computer equipment. <u>NOTE</u>: CFD models!

C. Maximize the "outside ambient temperature" environments contributions to the data center cooling process

Data Center Green Initiatives

- Data center best practice considerations (con't):
  - D. Optimize the electrical power distribution to the computing
  - E. Raise the temperature in the data center to the maximum levels permissible for a practical operation
  - F. Employ mechanical VFD where feasible
  - G. Monitor and record all infrastructure data

Part III

Reliability vs. Redundancy vs. Uptime – "The Data Center Green Initiatives" – Are They Compatible?

Reliability vs. Redundancy vs. Uptime-“The Data Center Green Initiatives”-Are They Compatible?

- Knowledge of energy efficiency – PUE – Green initiatives
- However:

A. Redundant UPS

B. Redundant Generators

C. Redundant Chillers/Towers

- The GOOGLE PUE
- Examples

Reliability vs. Redundancy vs. Uptime-“The Data Center Green Initiatives”-Are They Compatible?

Reliability vs. Redundancy vs. Uptime – The Data

- The Mix
  - A. Computer Hardware – Ranking?
  - B. Computer Software – Ranking?
  - C. Telecommunication (Data/Tele) – Ranking?
  - D. Facility Infrastructure – See our Reliability Scale 1-10
- Considerations to impact efficiency:
  - A. Disaster Recovery
  - B. Mirroring

Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

C. Modularity/Scalability

D. Cloud Computing

E. Virtualization

F. Power Factors

Reliability vs. Redundancy vs. Uptime-“The Data Center Green Initiatives”-Are They Compatible?

Data center facility infrastructure summary “reliability” rankings:

Numerical Ranking	Terminology	Summary Definition
(1)	Unreliable	Shared power and cooling, no generator, no fire separation (standard construction materials, no fire suppression)
(2)	Unreliable/Improved Power	Dedicated unconditioned power, shared building cooling, no generator, no TVSS, non-redundant air conditioning, no fire separation/wet or no sprinklers
(3)	Unreliable-Improved Power/Cooling	Independent power and cooling, no UPS, generator or TVSS, non-redundant dedicated A/C, no fire separation/wet or no sprinklers
(4)	Conditioned	Dedicated power and cooling, conditioned power (no UPS or generator), dedicated non-redundant A/C units, limited fire rating (<1hr, wet sprinklers)
(5)	Isolated	Dedicated power and cooling systems, single UPS (no back-up), no generator, non-redundant dedicated A/C units, fire rating of 1 hr, limited/wet suppression
(6)	Improved-Isolated	Dedicated power, UPS and cooling, redundant dedicated A/C units, no generator, fire rating of 1 hr, smoke detection/pre-action sprinkler system
(7)	Reliable	Dedicated power, UPS, cooling systems, redundant & dedicated A/C units, single back-up generator, fire rating 1 hr, intelligent detection system, pre-action sprinkler system
(8)	Reliable/Redundant	Dedicated & redundant power and cooling, redundant UPS, A/C, generators, dedicated generators/single fuel system, water and gaseous fire suppression, 1 hr fire rating, back-up fire suppression
(9)	Highly Reliable	Fully redundant: (power train, cooling systems), redundant UPS’s, A/C, generators, fuel systems, building enclosed generators/weather protected mechanical systems, gaseous fire suppression, back-up system, fire rating of 1 hr or greater
(10)	Geographically Hardened & Redundant	All redundant: (power train, cooling system, UPS systems, generators, fuel systems), early warning smoke detection, fire rating >2 hrs, full flooding gaseous suppression/back-up, site is compartmentalized, site is impervious to weather and geographic exposures, location minimizes exposure to jurisdictional closure from hazardous spill, acts of terrorism, sabotage or similar risks

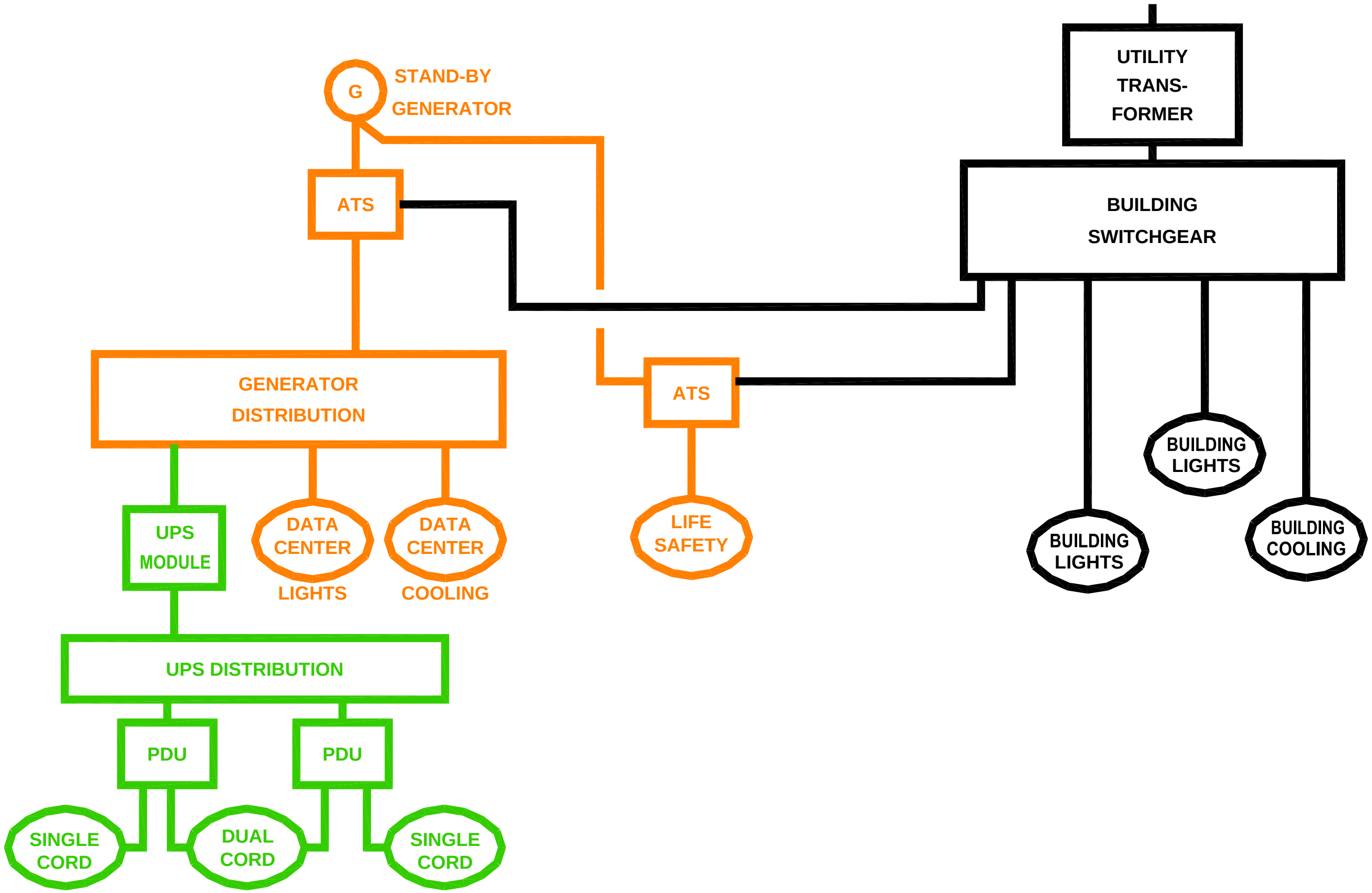
Reliability vs. Redundancy vs. Uptime-“The Data Center Green Initiatives”-Are They Compatible?

Reliability Alternatives

- N = Need (PUE low)
- N +1 = Need Plus One
- 2N = System Redundancy (Twice Need)
- 2N + 1 = System Redundancy Plus Component Redundancy (PUE high)

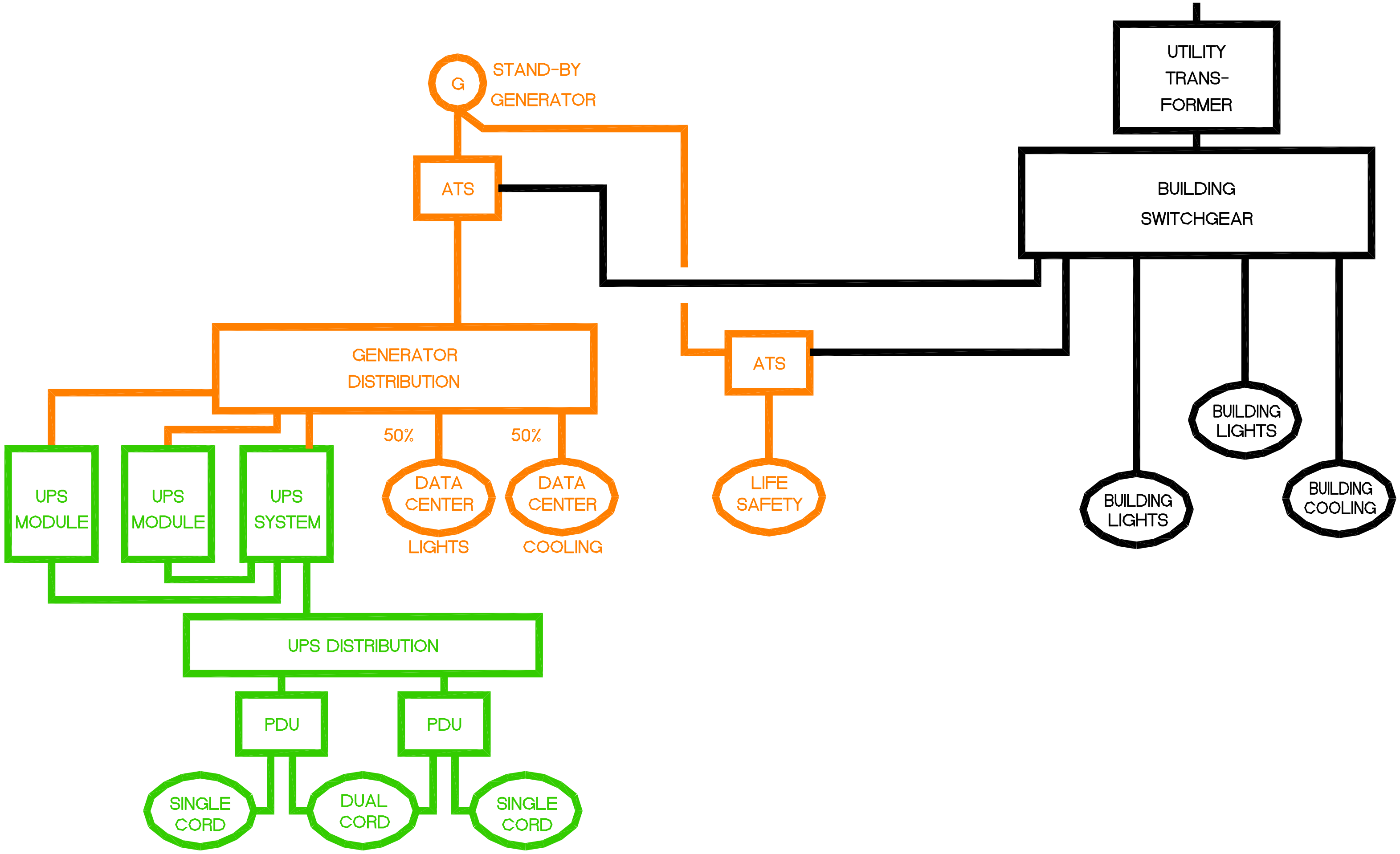
Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Electrical Diagram (N)



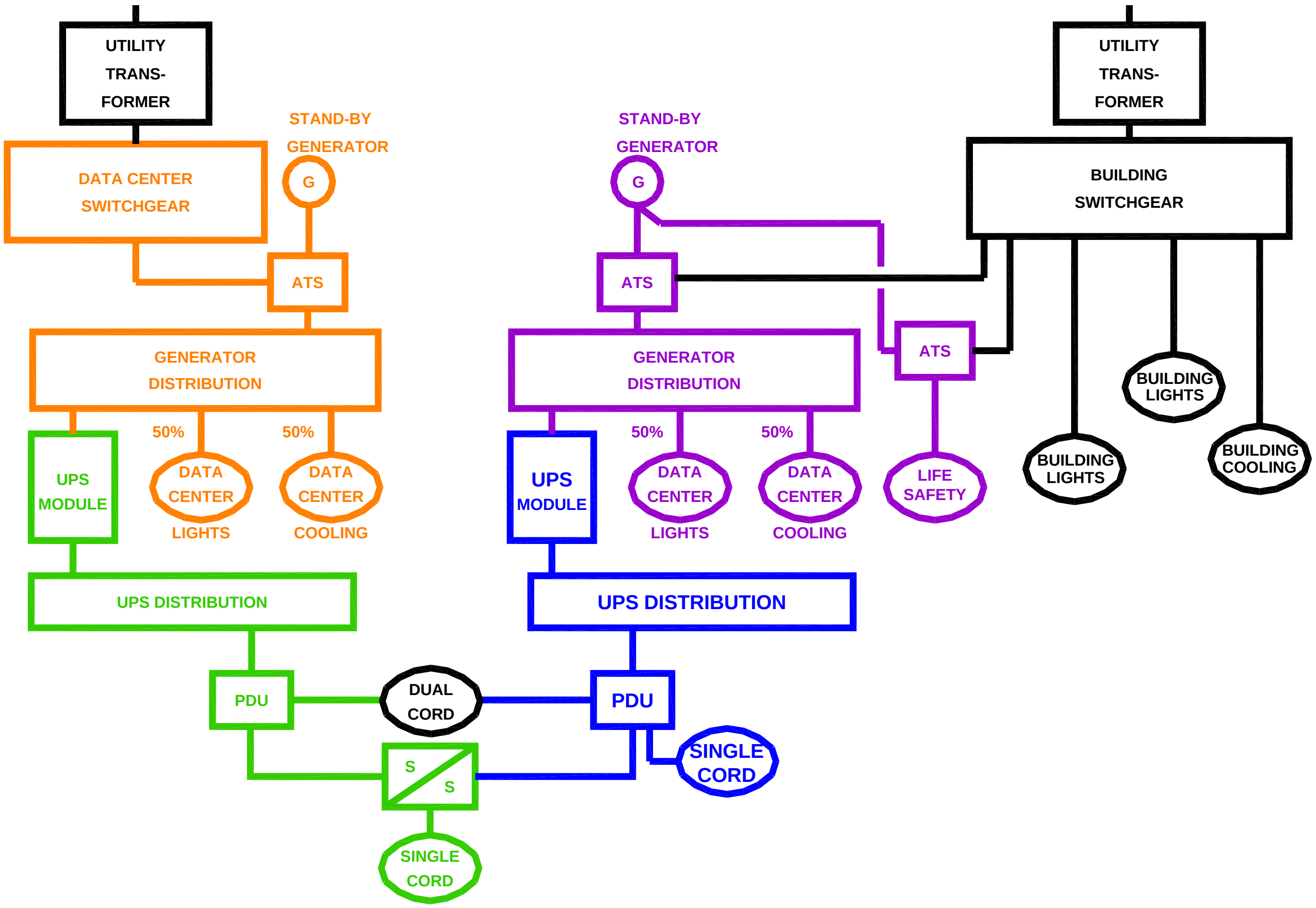
Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Electrical Diagram (N+1)



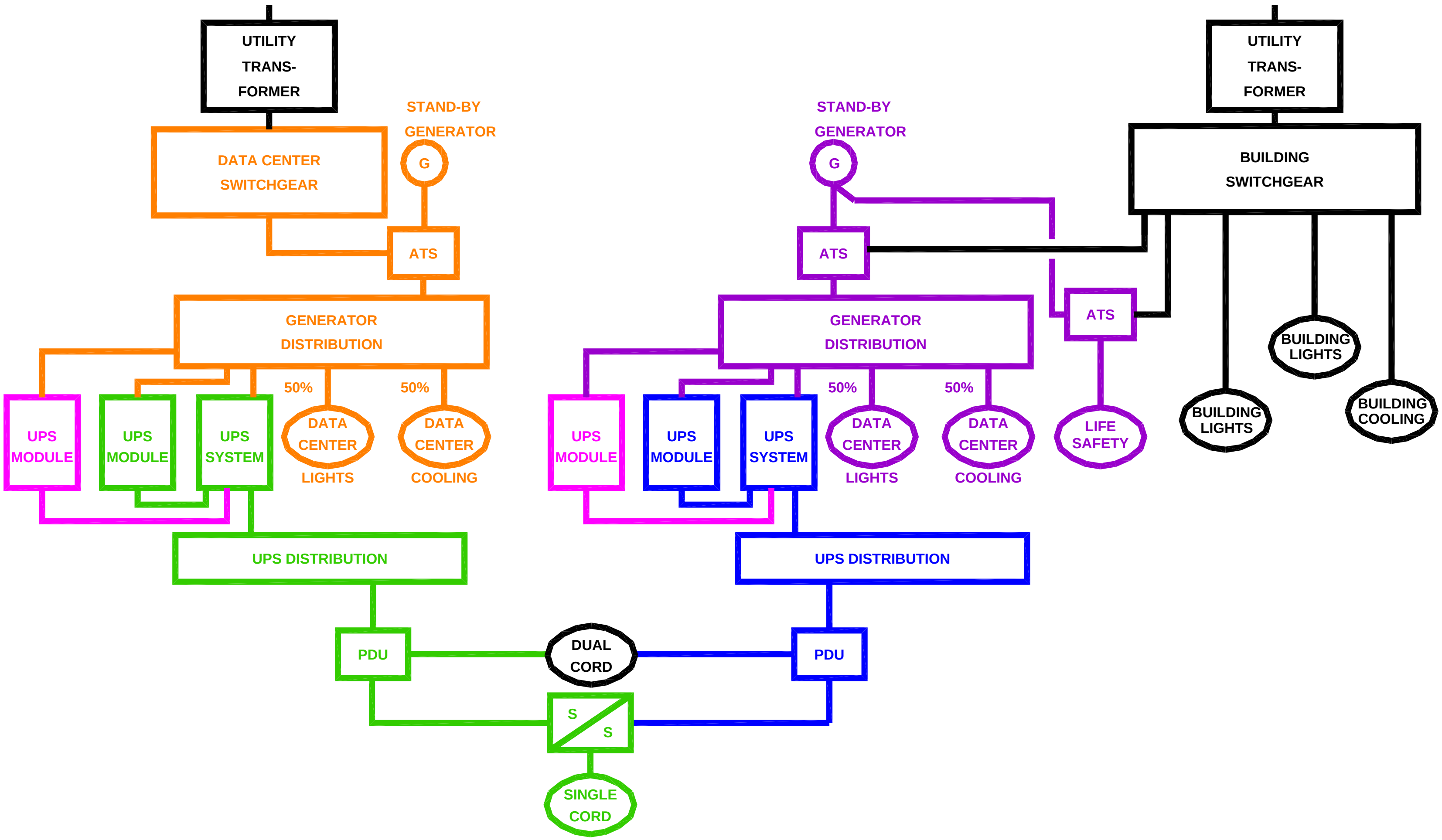
Reliability vs. Redundancy vs. Uptime-“The Data Center Green Initiatives”-Are They Compatible?

Simplified Electrical Diagram (2N)



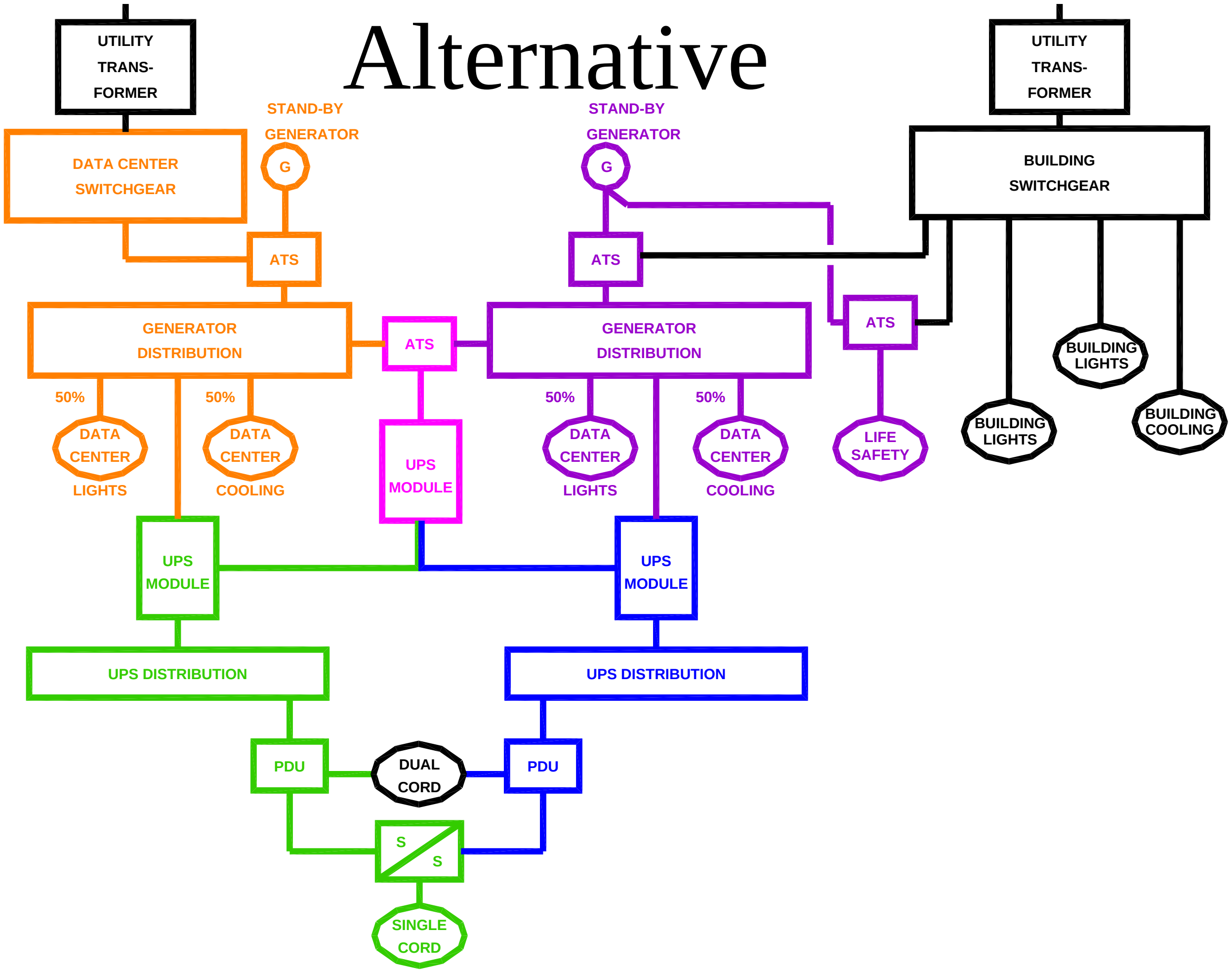
Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Electrical Diagram (2N+1)



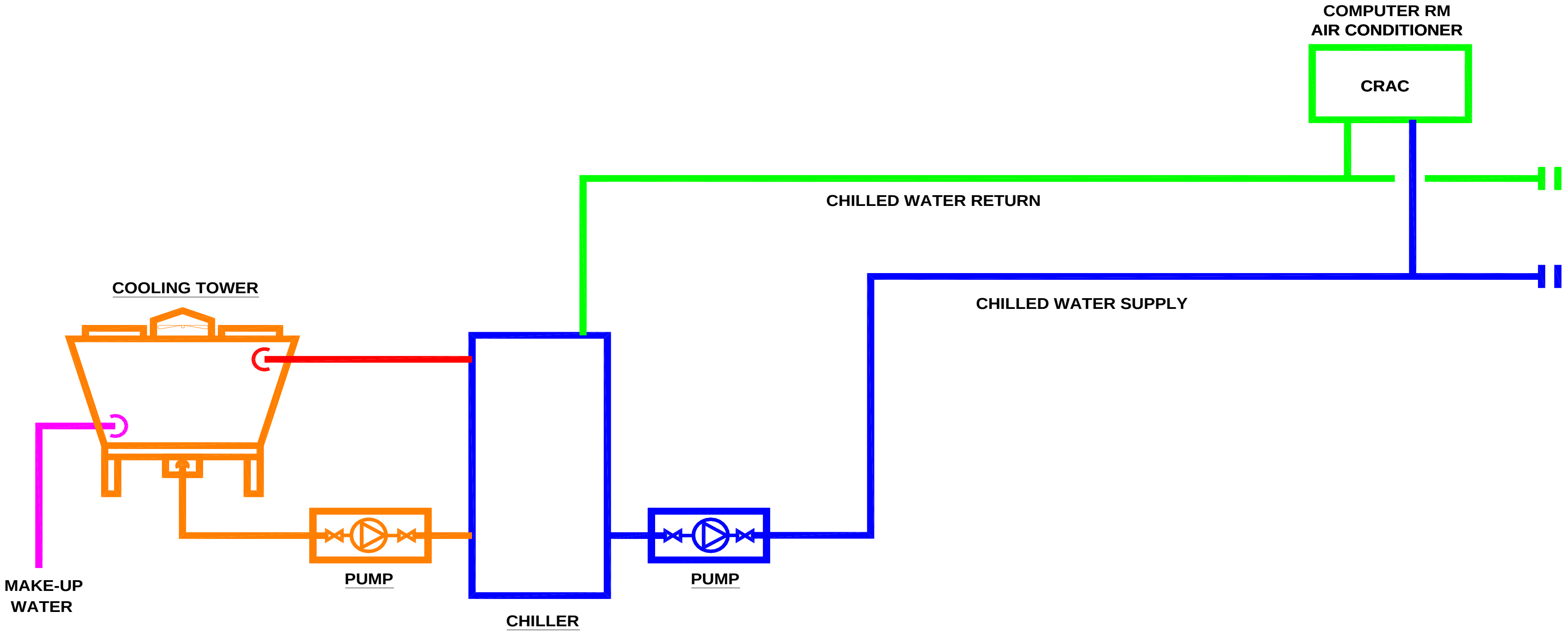
Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Electrical Diagram (2N+1) Alternative



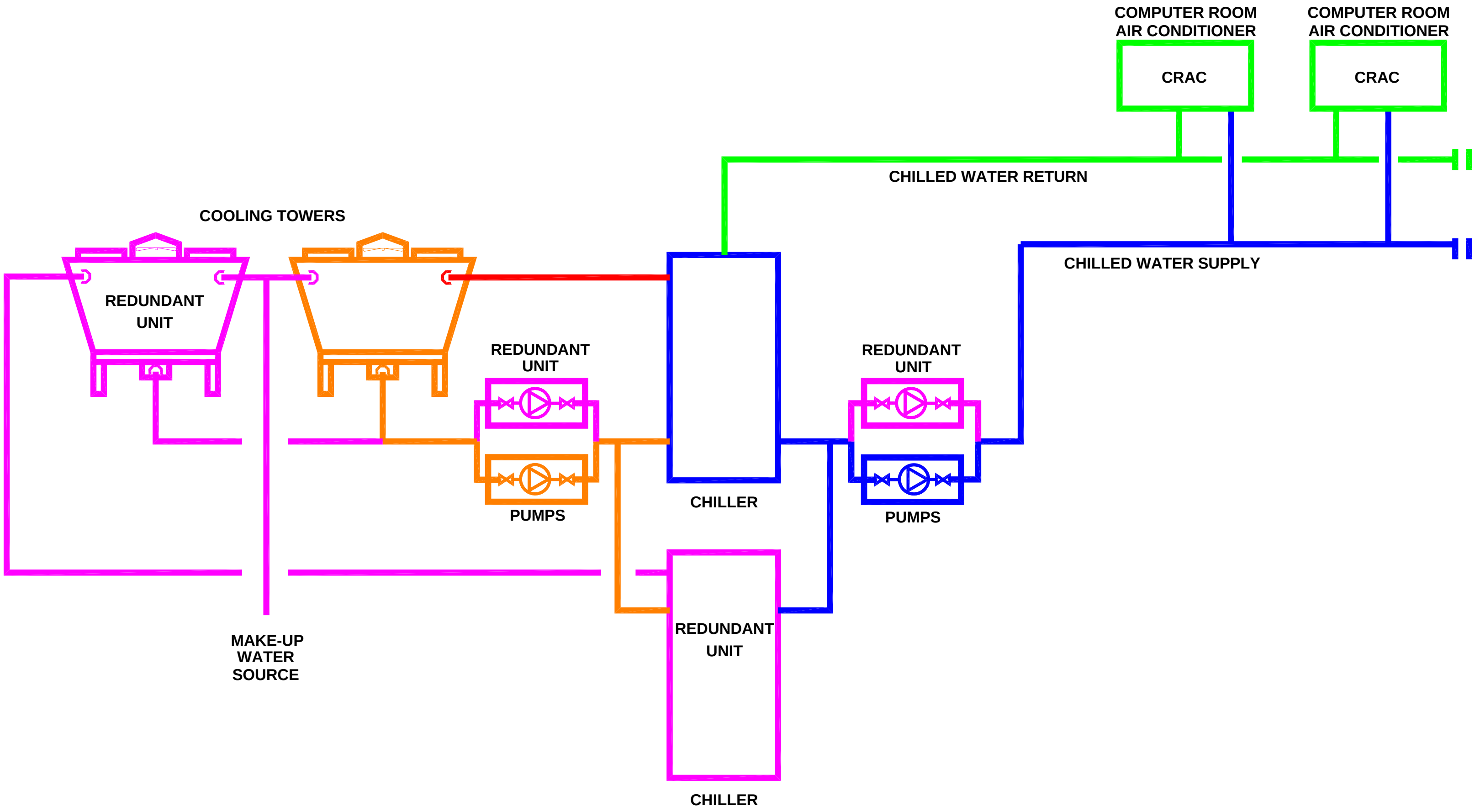
Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Mechanical Diagram (N)



Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Mechanical Diagram (N+1)



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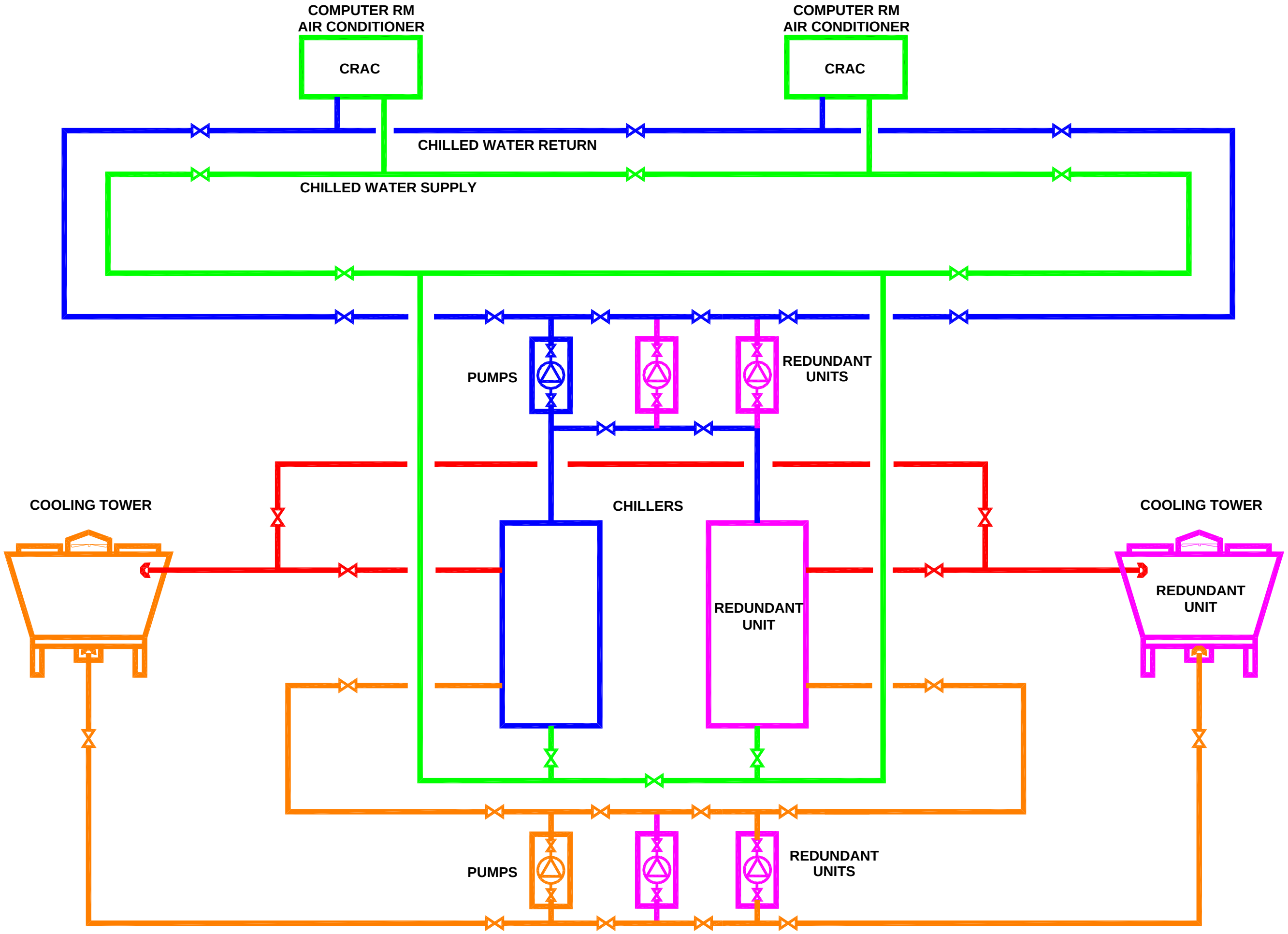
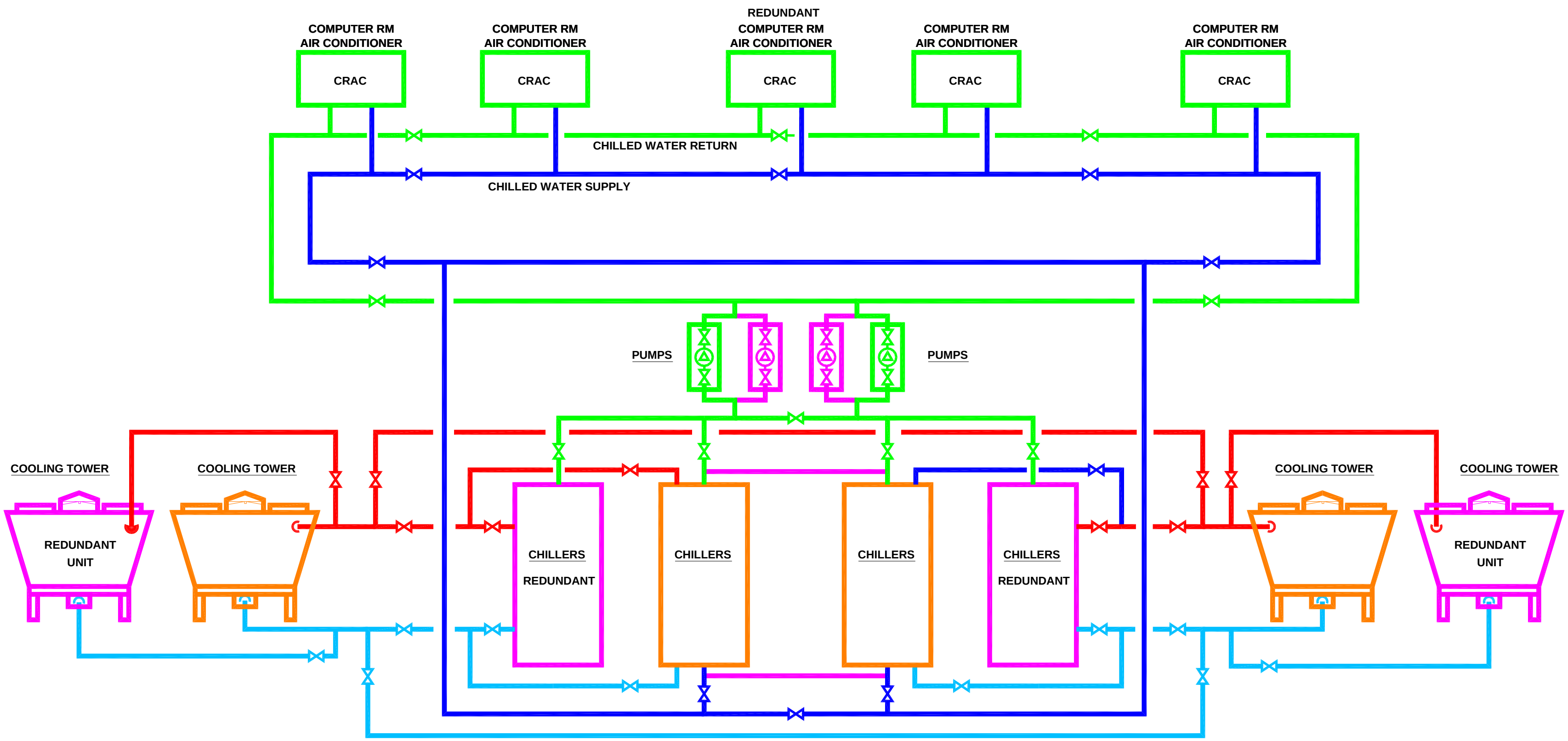
Simplified Mechanical Diagram (2N)



Reliability vs. Redundancy vs. Uptime-"The Data Center Green Initiatives"-Are They Compatible?

Simplified Mechanical Diagram (2N+1)



Part IV

The Role of LEED

The Role of LEED

- LEED – Leadership in Energy and Environmental Design
- Data Center Evolution
- LEED was originally focused on buildings
- United States Green Building Council (USGBC) Sponsored
- Point System from Design through Construction
- Monsanto “Green” Data Center

The Role of LEED

LEED 2009 for New Construction and Major Renovation

Project Checklist

Project Name

Date

Y	N	?				
0	0	0	**Sustainable Sites**		Possible Points:	26
Y			Prereq 1	Construction Activity Pollution Prevention		
			Credit 1	Site Selection		1
			Credit 2	Development Density and Community Connectivity		5
			Credit 3	Brownfield Redevelopment		1
			Credit 4.1	Alternative Transportation—Public Transportation Access		6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms		1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles		3
			Credit 4.4	Alternative Transportation—Parking Capacity		2
			Credit 5.1	Site Development—Protect or Restore Habitat		1
			Credit 5.2	Site Development—Maximize Open Space		1
			Credit 6.1	Stormwater Design—Quantity Control		1
			Credit 6.2	Stormwater Design—Quality Control		1
			Credit 7.1	Heat Island Effect—Non-roof		1
			Credit 7.2	Heat Island Effect—Roof		1
			Credit 8	Light Pollution Reduction		1
0	0	0	**Water Efficiency**		Possible Points:	10
Y			Prereq 1	Water Use Reduction—20% Reduction		
			Credit 1	Water Efficient Landscaping		2 to 4
				Reduce by 50%		2
				No Potable Water Use or Irrigation		4
			Credit 2	Innovative Wastewater Technologies		2
			Credit 3	Water Use Reduction		2 to 4
				Reduce by 30%		2
				Reduce by 35%		3
				Reduce by 40%		4

The Role of LEED

0	0	0	**Energy and Atmosphere**	Possible Points:	35

Y	Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y	Prereq 2	Minimum Energy Performance	
Y	Prereq 3	Fundamental Refrigerant Management	
	Credit 1	Optimize Energy Performance	1 to 19
		Improve by 12% for New Buildings or 8% for Existing Building Renovations	1
		Improve by 14% for New Buildings or 10% for Existing Building Renovations	2
		Improve by 16% for New Buildings or 12% for Existing Building Renovations	3
		Improve by 18% for New Buildings or 14% for Existing Building Renovations	4
		Improve by 20% for New Buildings or 16% for Existing Building Renovations	5
		Improve by 22% for New Buildings or 18% for Existing Building Renovations	6
		Improve by 24% for New Buildings or 20% for Existing Building Renovations	7
		Improve by 26% for New Buildings or 22% for Existing Building Renovations	8
		Improve by 28% for New Buildings or 24% for Existing Building Renovations	9
		Improve by 30% for New Buildings or 26% for Existing Building Renovations	10
		Improve by 32% for New Buildings or 28% for Existing Building Renovations	11
		Improve by 34% for New Buildings or 30% for Existing Building Renovations	12
		Improve by 36% for New Buildings or 32% for Existing Building Renovations	13
		Improve by 38% for New Buildings or 34% for Existing Building Renovations	14
		Improve by 40% for New Buildings or 36% for Existing Building Renovations	15
		Improve by 42% for New Buildings or 38% for Existing Building Renovations	16
		Improve by 44% for New Buildings or 40% for Existing Building Renovations	17
		Improve by 46% for New Buildings or 42% for Existing Building Renovations	18
		Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19

The Role of LEED

Credit 2	On-Site Renewable Energy	1 to 7
	1% Renewable Energy	1
	3% Renewable Energy	2
	5% Renewable Energy	3
	7% Renewable Energy	4
	9% Renewable Energy	5
	11% Renewable Energy	6
	13% Renewable Energy	7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	3
Credit 6	Green Power	2

The Role of LEED

0	0	0	Materials and Resources		Possible Points: 14
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
				Reuse 55%	1
				Reuse 75%	2
				Reuse 95%	3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2
				50% Recycled or Salvaged	1
				75% Recycled or Salvaged	2
			Credit 3	Materials Reuse	1 to 2
				Reuse 5%	1
				Reuse 10%	2
			Credit 4	Recycled Content	1 to 2
				10% of Content	1
				20% of Content	2
			Credit 5	Regional Materials	1 to 2
				10% of Materials	1
				20% of Materials	2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

The Role of LEED

0	0	0	**Indoor Environmental Quality**		Possible Points: **15**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1

The Role of LEED

0	0	0	**Innovation and Design Process**	Possible Points:	**6**
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1
0	0	0	**Regional Priority Credits**	Possible Points:	**4**
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1
0	0	0	**Total**	Possible Points:	**110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

The Role of LEED

WHY
BUILD
GREEN?

On average, green buildings save:

40% in water use

30% in energy use
and greenhouse gas emissions

50–75% of construction
and demolition waste going to landfills

$58 billion
of sick time from work annually

Green buildings add

$180 billion
in increased worker
productivity annually

So why wouldn't you build green?

Part V

Data Center Costs Impacts and Trends

Data Center Cost and Impacts and Trends

- One of the Most Dangerous/Variable Factors in Design/Building a Data Center in 2010 and Beyond
- 1980/1990 “Rules of Thumb” in “cost per sq. ft.” Danger
- Same sq. ft. Data Center – ie: 4,000 sq. ft. – vary density, reliability, location, long term growth projection, scalability…$680 sq. ft. - $3,210 sq. ft.
- The “Throw Away” Data Center
- The Gartner Mission
- The Scheduled Delivery?

Data Center Cost and Impacts and Trends

A. Data center facility infrastructure cost impacts

- Physical size (See 1-5 year computer equipment plan – CRITICAL)
- Electrical/mechanical capacity
- Reliability level (See 1-10 chart)
- Expandability
- Retrofit vs. New – WARNING!
- Time allocated to complete the project
- Location in the United States or Canada
- Type of construction labor force
- Support Space

Data Center Cost and Impacts and Trends

B. Summary data center facility infrastructure cost experiences:

Numerical Ranking	Size (sq.ft.)	Cost/sq.ft.
10	15,000	$
	1,000	$
7-9	15,000	$
	1,000	$
5-7	15,000	$
	1,000	$
1-5	15,000	$
	1,000	$
Office	---------	$

NOTE: These cost experiences are not intended to be used as detailed budgets

* Electrical Density Cost differences per mw.

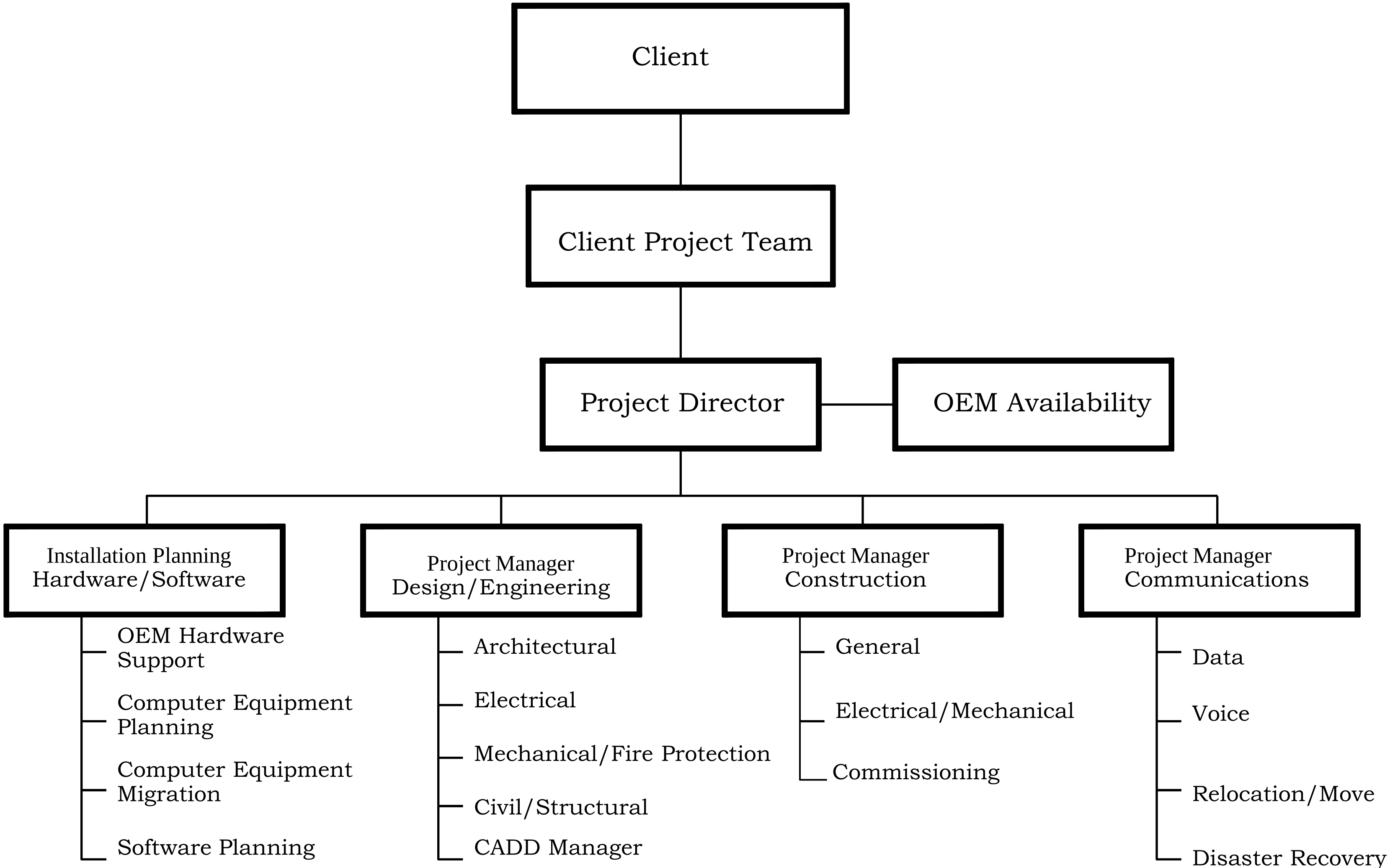
Data Center Cost and Impacts and Trends

Schedule duration for "typical" projects:

Item	Area	Description	Duration
1	Evaluations	To determine technical alternatives/costs/schedules associated with "type" of data center	10-14 weeks
2	Design/Engineering	Detail drawings/specifications for the "option" selected in 1	8-22 weeks (excludes a building shell)
3	Permits	For local authorities to review/approve	Allow 4 weeks
4	General Construction	A function of reliability, size, and location	16-30 weeks (excludes a building shell)
5	Pre-Purchase/Long Lead Time Equipment	New Update Economic Decline	Up to 46 weeks
6	Thermodynamic (CFD) Modeling Projects	Stand alone base on information technology	10 – 16 weeks

Data Center Cost and Impacts and Trends

Project Team

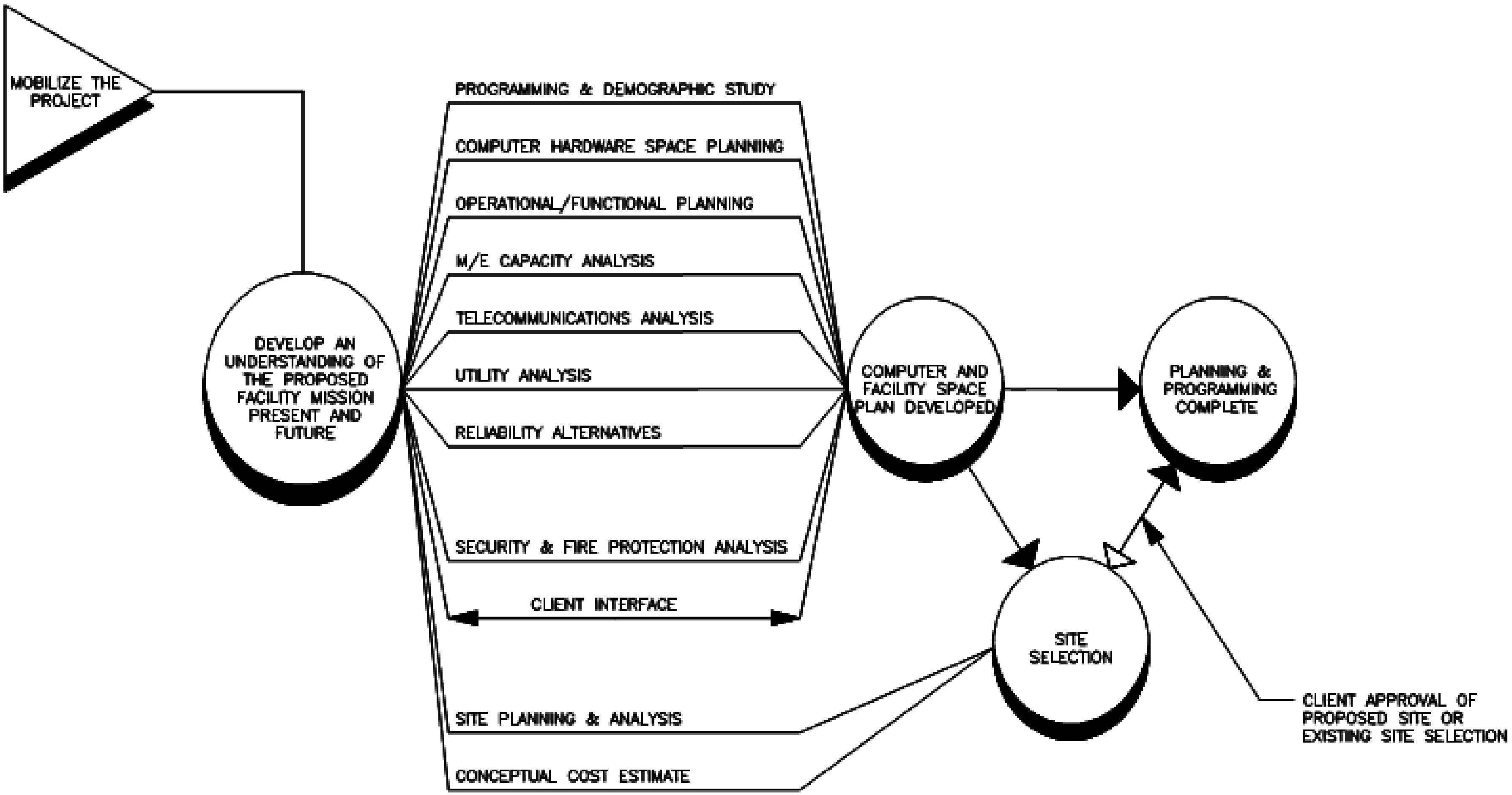


Data Center Cost and Impacts and Trends

Data Center Facility Infrastructure Efficiency Process

- Consulting – Evaluations, Requirements, Options, Alternatives, Budgets, and Schedules of the “Mix”
- Design/Engineering – Follows the Consulting Process
- Construction/Commissioning

Data Center Cost and Impacts and Trends

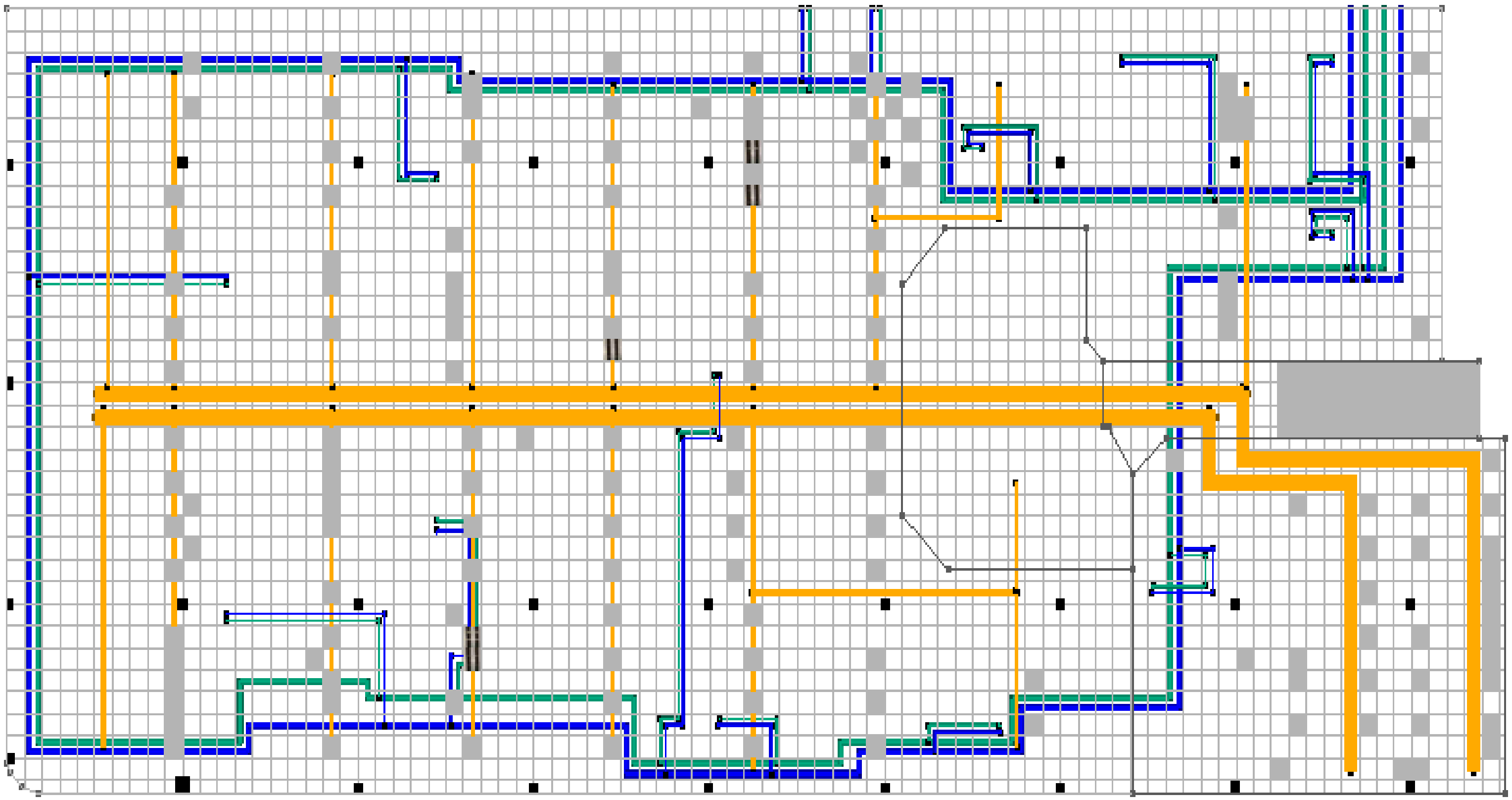


Part VI

Sample CFD Slides

CFD Thermal Analysis

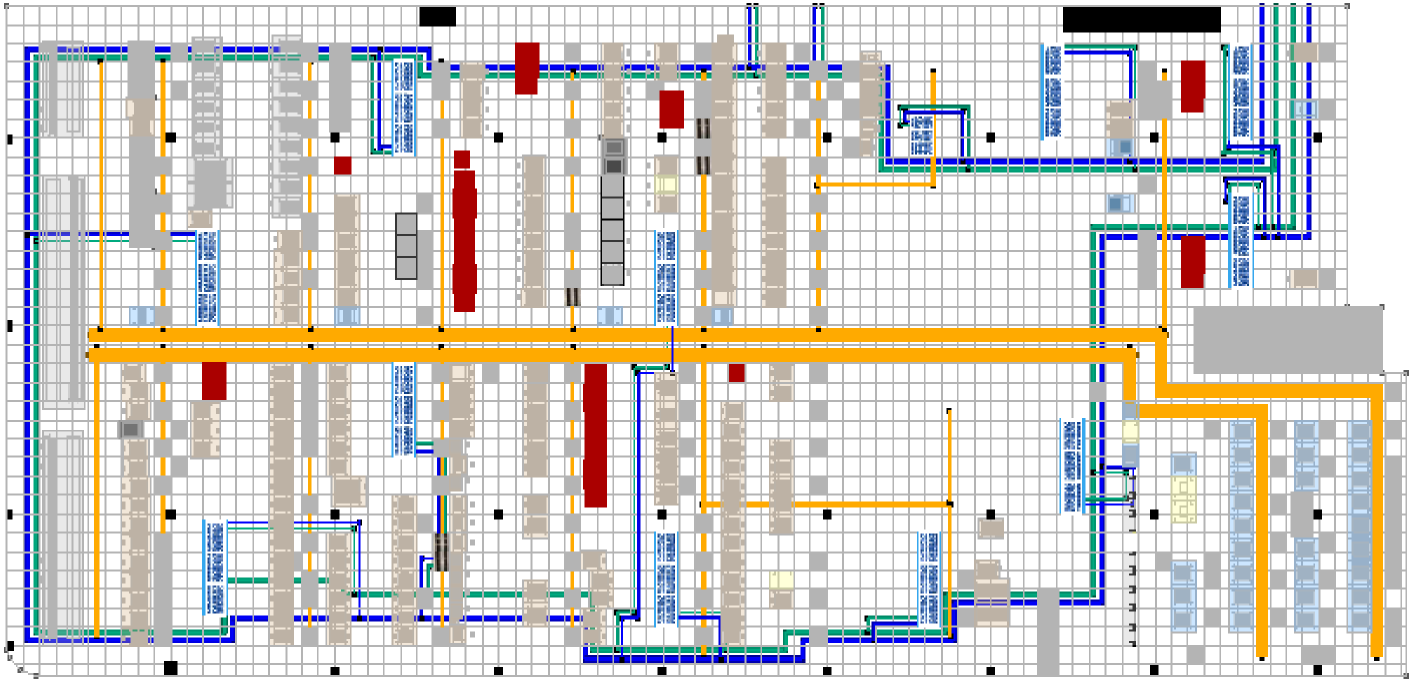
Base Model



The Shell, Underfloor, and Raised Floor

CFD Thermal Analysis

Base Model



The Shell, Floor, CRAC's, PDU's, and Equipment

CFD Thermal Analysis

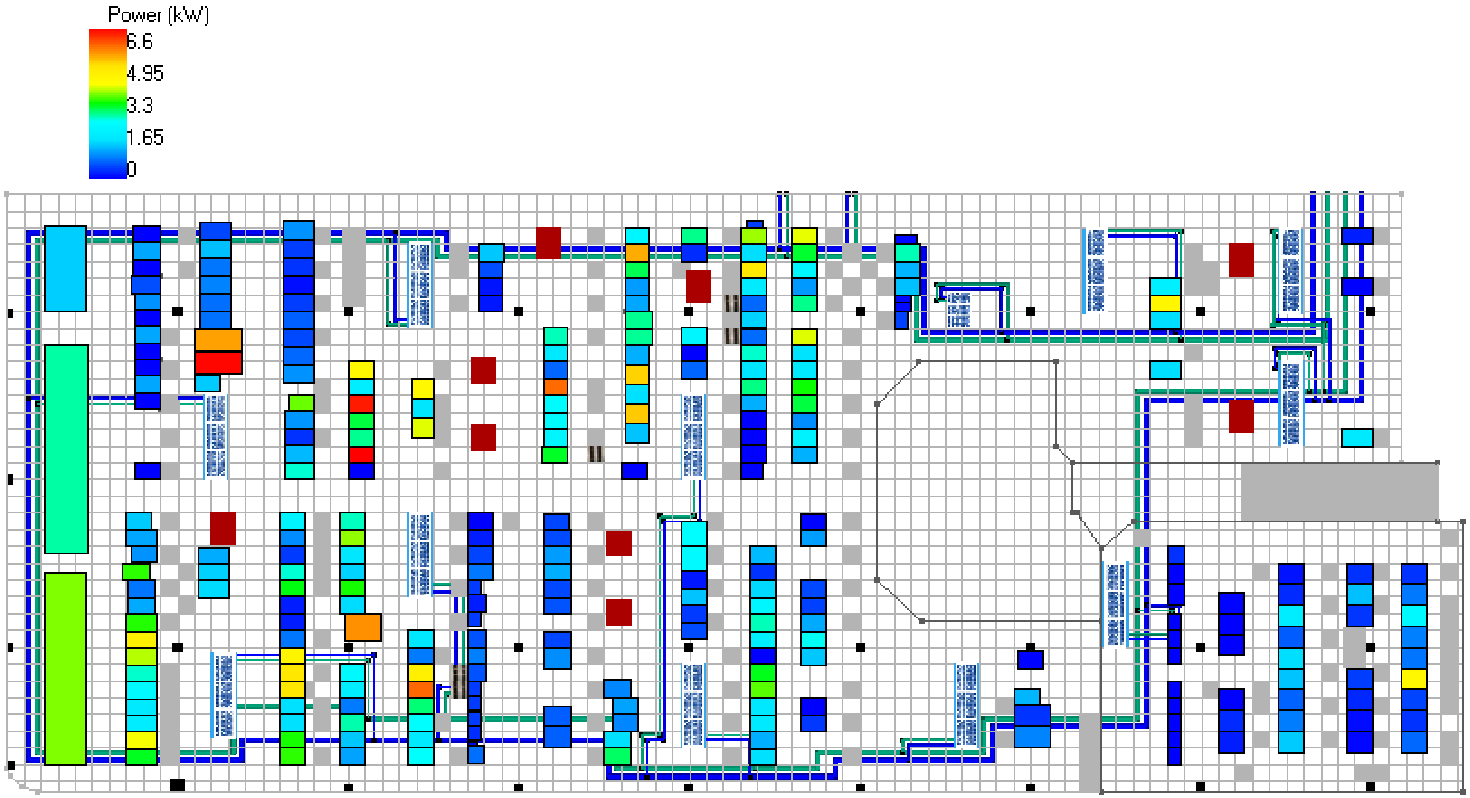
Base Model

Equipment Orientation

The equipment orientation is shown as the intake side of the units being blue and the exhaust side being red. It can be seen that not all equipment is orientated in a hot and cold aisle configuration, and not all equipment within the same row is oriented in the same direction. There are some front to back oriented equipment racks as noted earlier. These racks will have a tendency to pull in hot exhaust air from the rack in front them.

CFD Thermal Analysis

Base Model

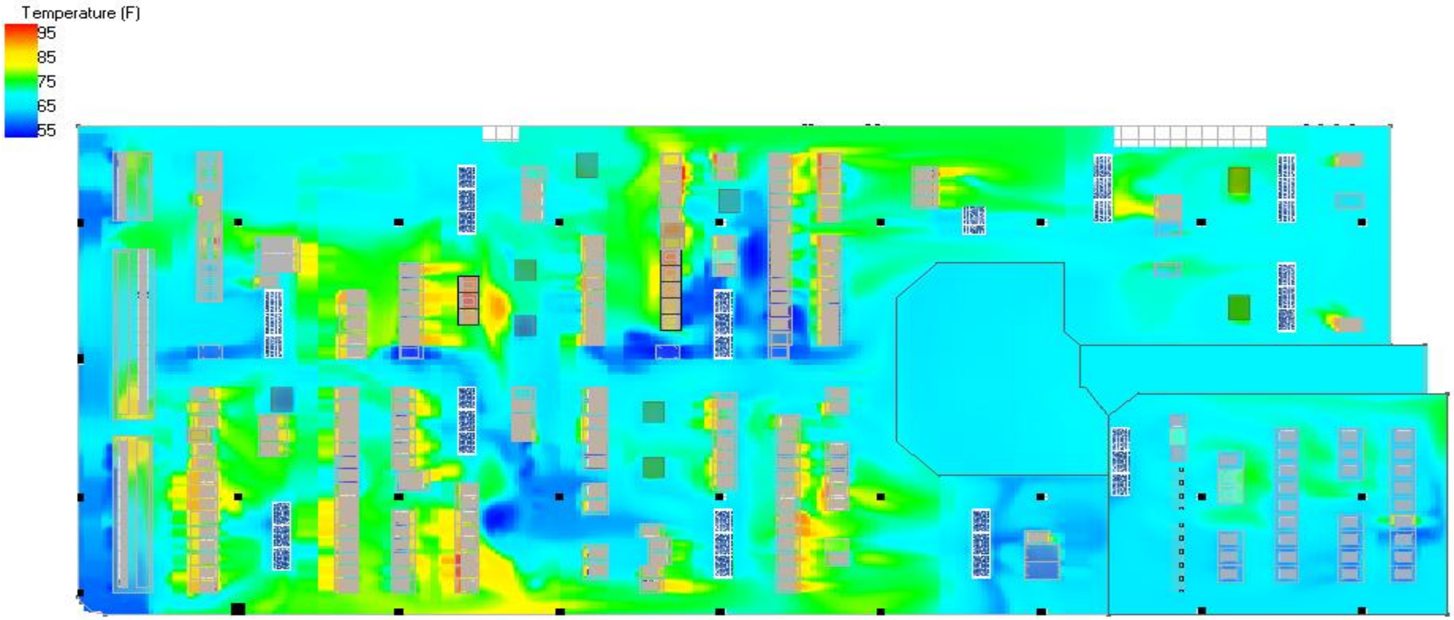


Equipment Powers

The equipment demand can be seen here in kW.

CFD Thermal Analysis

Base Model

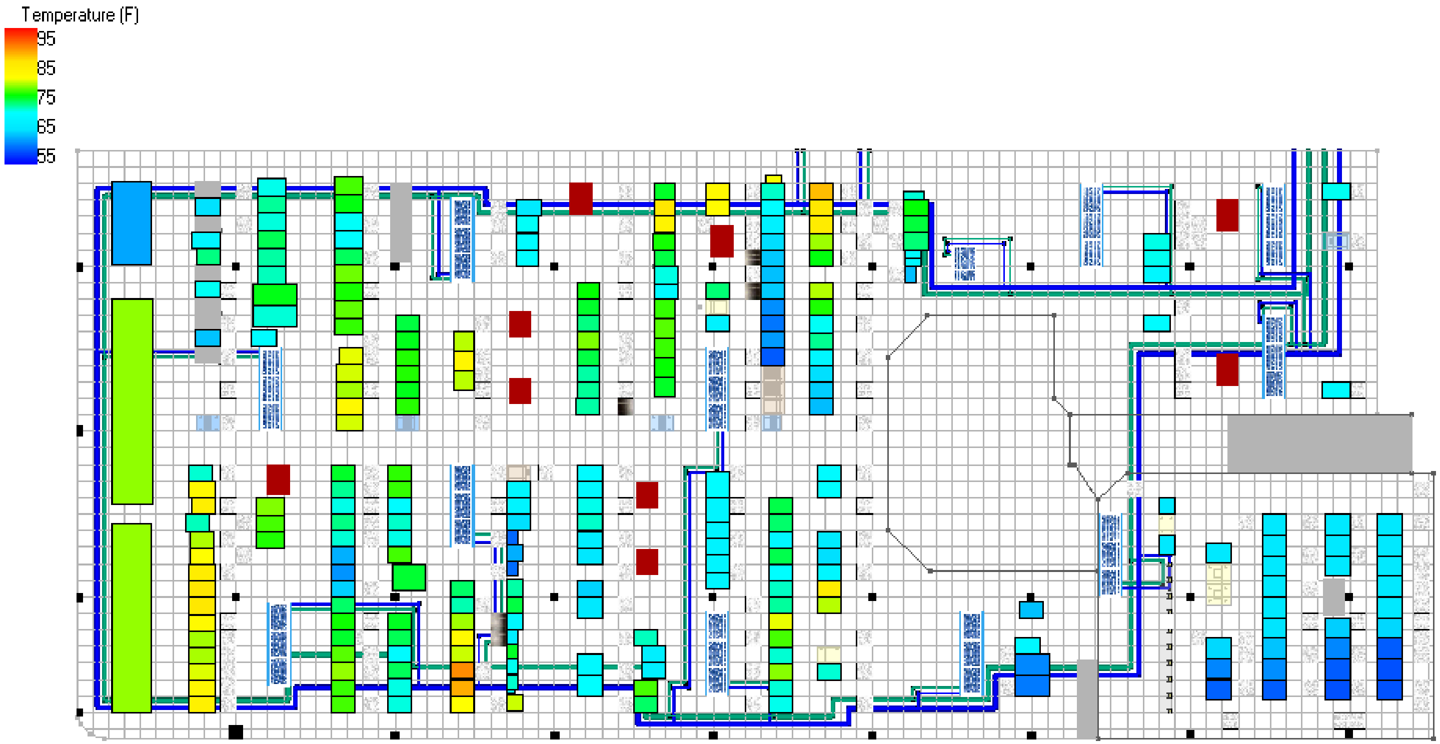


Top of Rack Temperatures

The top of the equipment rack is typically where the highest intake temperatures are seen in the data center. This is a result of this part of the rack receiving less supply air from the underfloor plenum, the higher ambient temperatures at this level of the room, or the recirculation of hot air due to low ceiling heights. It can also be seen that some cold air is being returned to the CRAC units while warm air is being exhausted into the intake of other equipment. Some short cycling is occurring where perforated tile placement allows colder air to return to the CRAC units.

CFD Thermal Analysis

Base Model

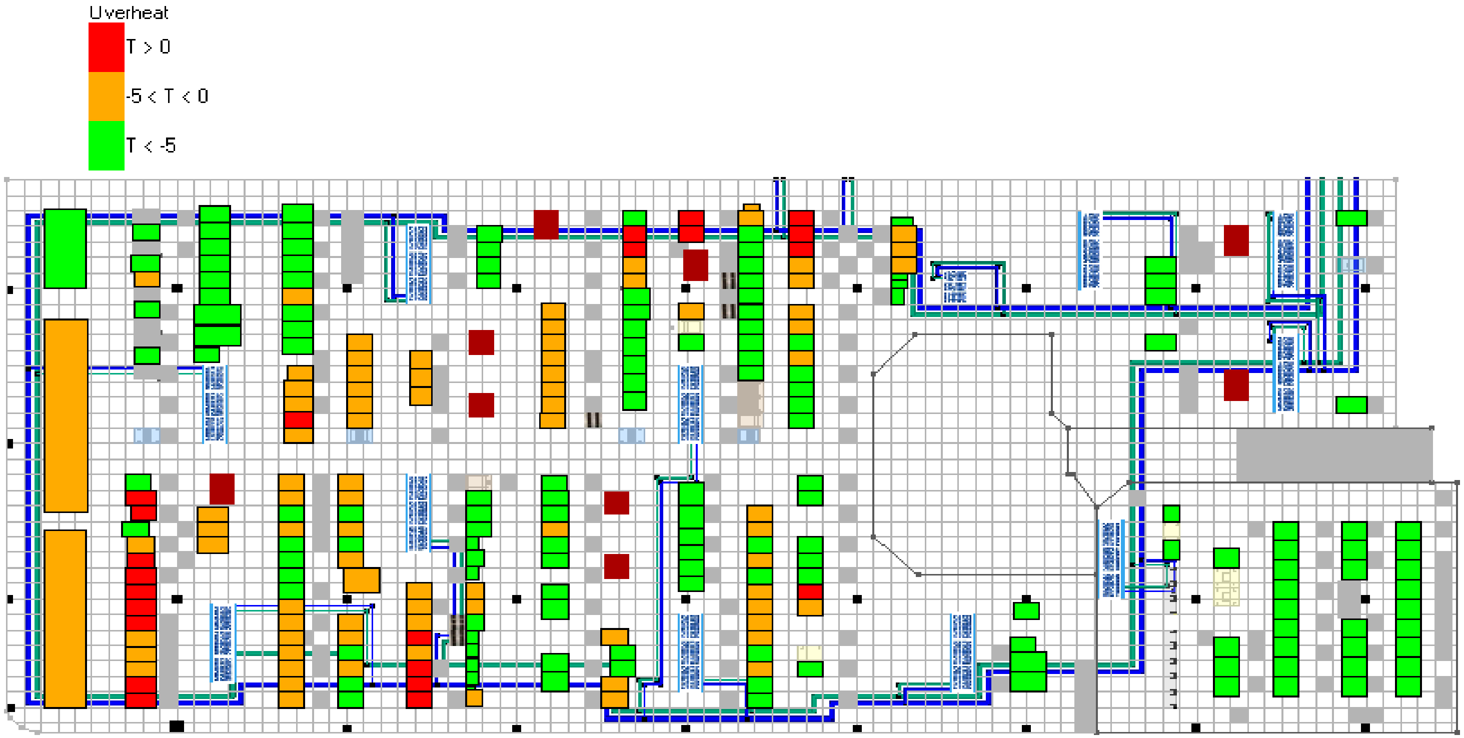


Maximum Equipment Inlet Temperatures

The ASHRAE recommended inlet temperature for computer equipment is between 68 and 77 deg F. This temperature is exceeded in several areas shown as green and yellow. These temperatures however are still within the allowable ASHRAE range of 59 to 90 deg F.

CFD Thermal Analysis

Base Model



Potential Equipment Overheat

This indicates which racks may be at risk of thermal failures due to high intake temperatures. The specific rack configurations may negate such risk if no devices are installed in the top of the rack or if devices such as patch panels are installed at the top of the racks.

Part VII

Questions and Answers

General Discussion

Q = CIA √

Y = MCA X

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