Federal Electronics Challenge (FEC) Partner Webinar

Greening our Federal Data Centers

February 3, 2011

Dan Gallo, Chris Newman, EPA

William “Kenny” Floyd, NIH

John Rucker, VA

Key Points From November 2010 Data Center Webinar:

- Quick payback can be achieved through data center improvements:
  - DOD-Hawaii invested $252,499 and will save $160,020 per year, along with reducing CO_2 emissions by 425 tons per year!

Key Points From November 2010 Data Center Webinar (continued):

- Help is available to Federal agencies:
  - DOE resources are available for feds:
    - Guidance: http://www.energystar.gov/index.cfm?c=fed_agencies.fed_ag_index
    - Training: 1-day training; 3-day training
      - http://www1.eere.energy.gov/industry/datacenters/training.html

Key Points From November 2010 Data Center Webinar (continued):

- DOE Federal Energy Management Program (FEMP):
  - Data Center Initiative: Coordinator: William Lintner: William.lintner@ee.doe.gov
    - is getting a lot of requests for technical assistance from federal facilities
    - ENERGY STAR for Data Centers: R.J. Myers, Una Song
      - http://www.federalelectronicschallenge.net/resources/docs/greener_data_center.pdf

Potential Impact of Data Center Improvements:

- The EPA report to Congress estimated that if state-of-the-art technology were adopted then energy efficiency could be improved by **as much as 70 percent**

  (Report to Congress on Server and Data Center Energy Efficiency, Public Law 109-431, U.S. Environmental Protection Agency, ENERGY STAR Program, August 2, 2007.)

FEC Webinar: Data Centers

John Rucker
Department of Veterans Affairs

VA Overview

2nd Largest Federal Agency

5 data Centers

- Austin
- Chicago (Hines)
- Philadelphia
- Falling Waters, WV
- Quantico, VA

Medical Center IT decentralized but…

About $100 Billion in processing

Green Challenges

- Aging Infrastructure
- The Color of Money
- FDCCI
- National Data Center Program

Green Responses

$10M in ARRA for Austin

- Chilled Water
- Solar Panels

Incremental Improvements Do Add Up

Power Management: Night Watchman

UNICOR end of life

www.green.va.gov

Cloud Computing

Federal Data Centers Grew From 432 in 1998 to More Than 1,100 Today

The Federal Government's "Cloud First" Strategy

http://www.cio.gov/documents/25-Point-Implementation-Plan-to-Reform-Federal%20IT.pdf

Virtualize & Consolidate

What Is Cloud Computing?

NIST Provides the official definition here:

http://csrc.nist.gov/groups/SNS/cloud-computing/cloud-def-v15.doc

Cloud computing is a model for enabling highly-available, convenient, on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Translated Into English…

Virtualize servers, get more bang for the buck out of each physical box

Makes it easy to clone systems for rapid provisioning

More user control at some levels

The Green Angle

Fewer systems = lower electrical bill, at least in theory

Fewer systems reduces carbon footprint

Fewer systems = easier tracking for end of life excess

Fewer systems = smaller data centers

Not A Silver Bullet

Not all systems can be easily virtualized. Federal developers need to take Cloud First to heart in systems design

Security Concerns

Private Cloud vs. Public

Follow Up

VA Cloud Document – Ask Your IT Staff About Their Cloud Strategies

Working With GSA to Ensure We Lease Green Data Centers

steve.gavenda@va.gov (facilities) or john.rucker@va.gov (management)

Questions?

Office of Research Facilities

Data Center Energy Management

A review of strategies for "greening" data centers

Kenny Floyd
National Institutes of Health

Sustainable Data Centers: Background

- Data centers use 1.5% of all power in the U.S (Lawrence Berkley National Laboratory study)
- IT power consumption expected to double by 2015 (EPA)
- Annual electricity cost ~$7.4 billion by 2011, with **10%** government.
- ~60 % data center power used for facilities power and cooling

- **BOTTOM LINE….DATA CENTERS ARE ENERGY HOGS!**

Data Center Efficiency: PUE

- Power usage effectiveness (PUE) is a metric used to determine the energy efficiency of a data center. PUE is expressed as a ratio, with overall efficiency improving as the quotient decreases toward 1.

- Servers / Storage / Telco equipment vs Total facility power including
  - Switchgear / UPS / Battery backup / Cooling

Data Center Power

DELIVERY COMPONENTS

- Emergency Back up systems
- Choose a UPS with a 95%+ efficient IGBT *(Insulated-gate bipolar transistor)* inverter and rectifier
- Utilize DC power over AC power
- Think Modular!
- New generation battery, flywheel and diesel generator back up.

Data Center Power

COOLING SYSTEMS

- Ensure that cabinets are oriented to prevent the mixture of hot and cold air.
- If possible, use containment measures to prevent hot air from mixing with cold air.
- Keep air handlers as close to the IT equipment as possible.
- Use free (outdoor) cooling.
- Enable Active Energy Management/Metering
- Plan for liquid cooling.

Data Center Power

IT EQUIPMENT POWER

- Purchase high efficiency equipment
- Server Consolidation
- Install Blade Servers
- Virtualization (Cloud Computing)

Data Center Power

IT SUPPORT EQUIPMENT

- **Install automated lighting**
- **Set both tactical and strategic green goals.**
- **Plug openings (cables, power) not in cold aisle.**
- **Cables overhead – even power!**

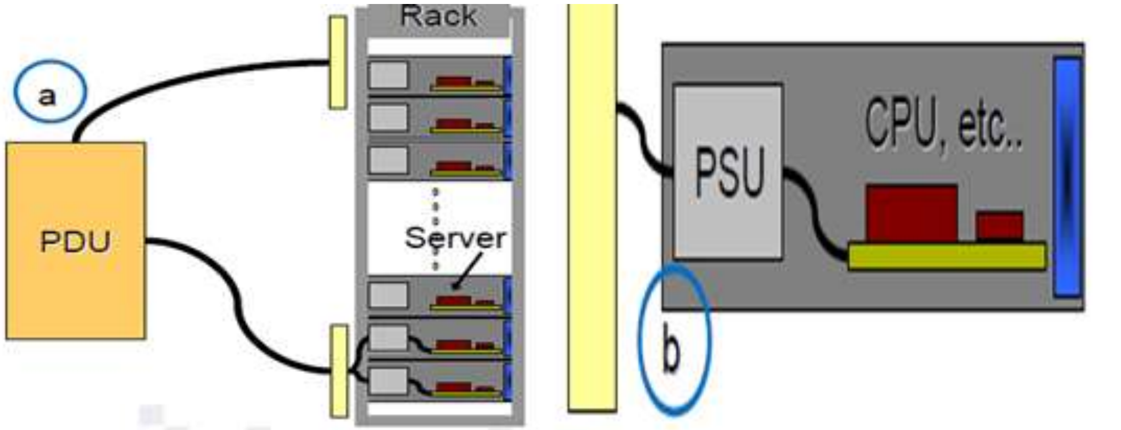
METER STRATEGY

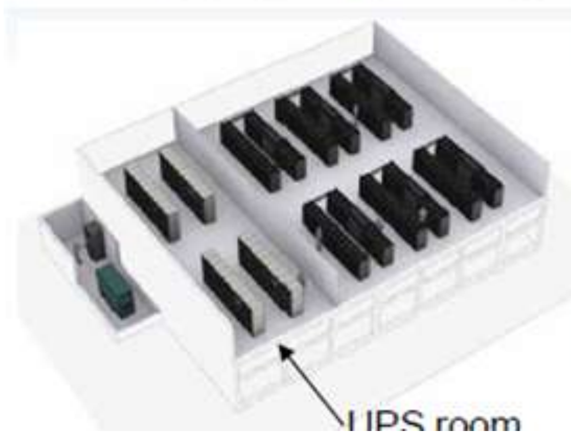
Figure Depicting Data Center Metering Set up

- Many data centers have plenty of meters for each sub-system

- There are numerous attributes within the data center that require metering and measurements
  - Temperature
  - Flow Rates
  - Current
  - Pressure
  - Voltage
  - Humidity

- However, they are installed to measure capacity or facility health, **not enterprise efficiency!!**





Where to measure actual IT Energy?

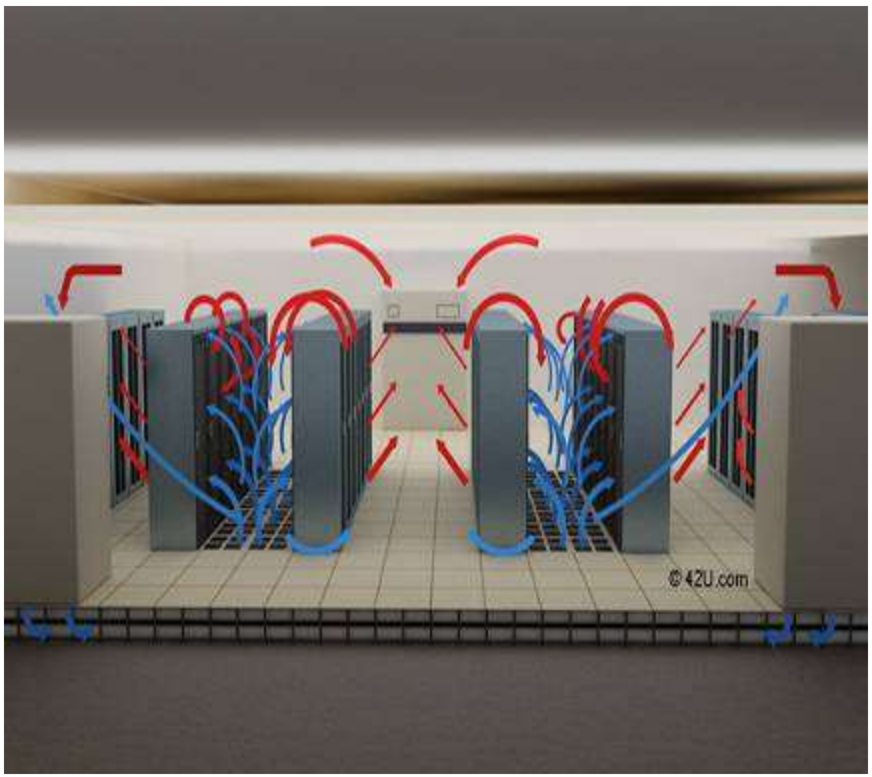
Picture depicting energy metered at Power Distribution Unit / Power Supply Unit / Central and Distributed Uninterruptable Power Supplies

What else should I meter?

- **Racks -**
  - Hot & Cold Aisle Temperature
  - Humidity
  - Bypass & Recirculation airflow %
  - Rack Cooling Index (RCI)
- **Sub-floor:**
  - Differential pressure between plenums and the raised floor.
- **Chilled Water Flow:**
  - An ultrasonic flow meter measures water temperatures and flow rate
- **CRAC/CRAH:**
  - Supply & Return Temperature
  - Humidity (RH and dew point)
  - Air Loss %
- **PDU/RPP:**
  - Branch circuit monitoring
  - Power Panel Monitoring

Cooling Systems

Diagram of a Data Center with Bypass Air problems (mixing of hot and cold air)

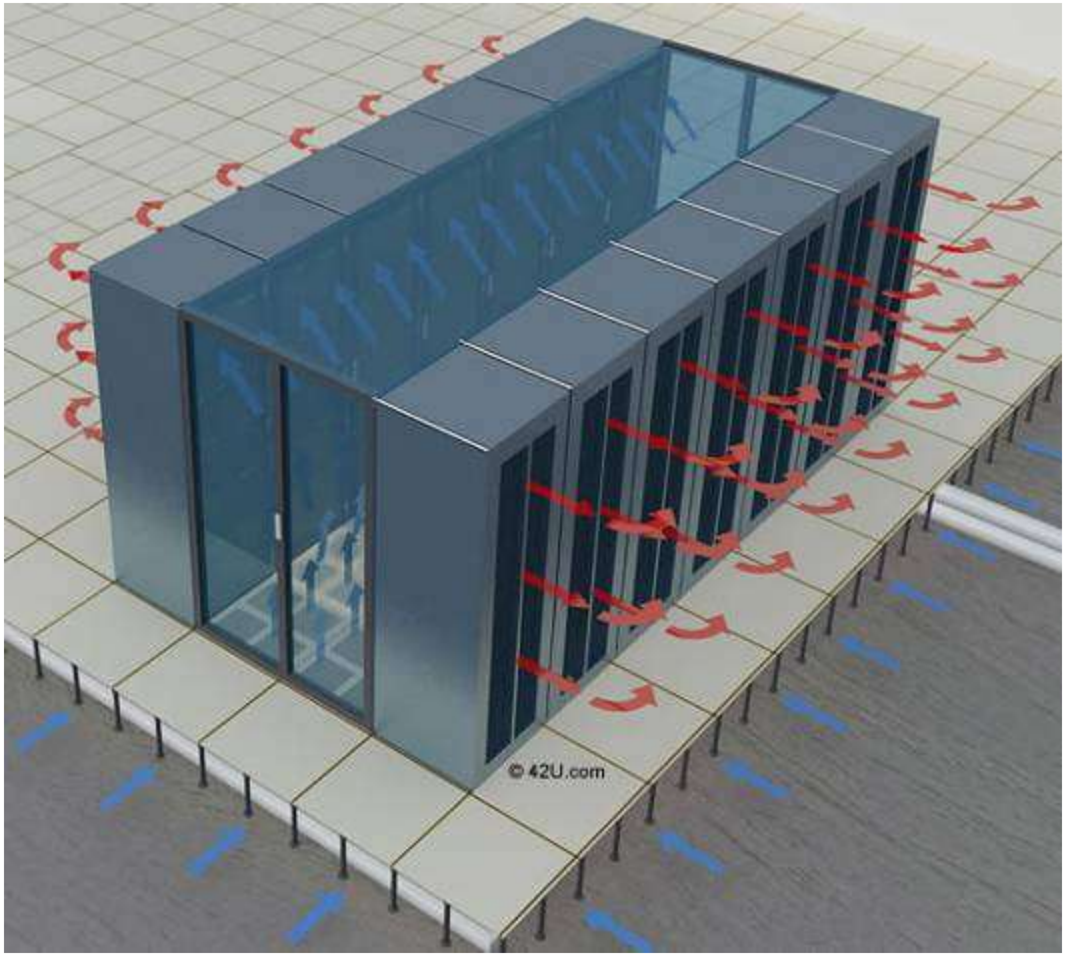


Traditional Data Center Design

- The traditional approach to cooling data centers is to place servers rack in large open aired rooms which utilize a number of computer room air condition units (CRAC units) to re-circulate hot air and provide cooling at all times.

- These units cool air temperatures of up to 126F back down to 68F, which requires an enormous amount of energy.

Depiction of Cold Aisle Containment

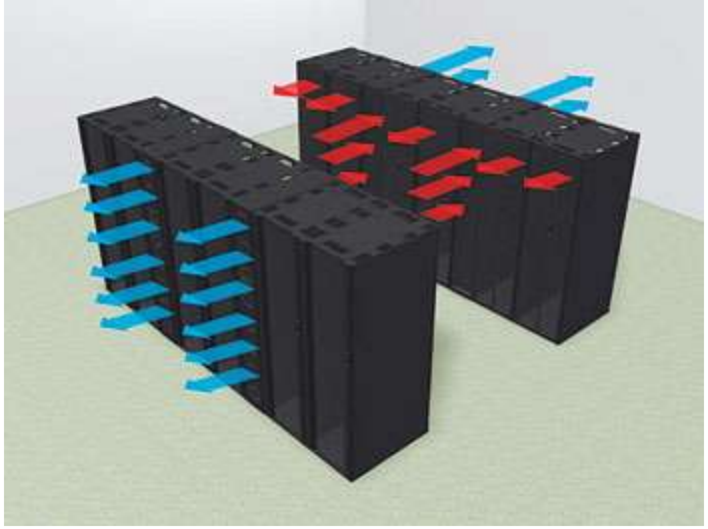


Liquid Cooling

In-Row Liquid Cooling

•In-Row units provide localized air distribution and management.

• Chilled water or refrigerant piping runs overhead or under floor to each individual cooler

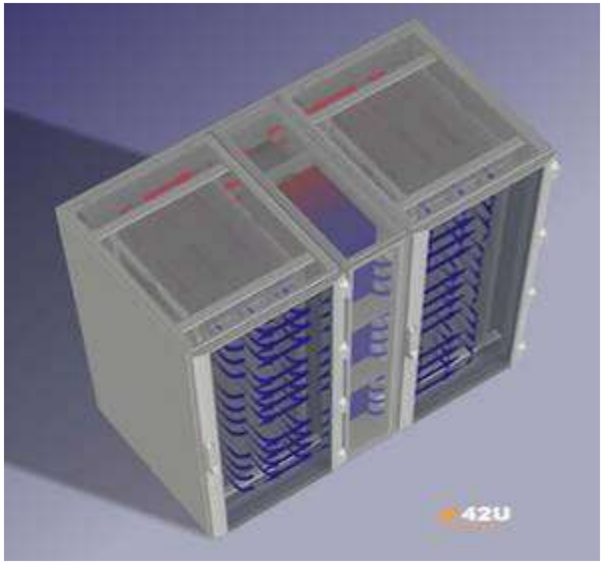


In-Rack Liquid Cooling

•In-Rack products contain both cold and hot airflow paths.

• Enclosed server rack microclimate thermally neutral to the room.

•In-Rack cooling products requires chilled water supply and return piping.



Cooling Mediums

Overhead Liquid Cooling

- Overhead cooling suspends from the ceiling to complement a hot aisle/cold aisle arrangement.
- As hot air rises from the hot aisle, the overhead cooler captures it, conditions it, and releases it back to the cold aisle.

Data Center Consolidation Initiative

Promote

- Promote the use of Green IT by reducing the overall energy and real estate footprint of government data centers.

Cost

- Reduce the cost of data center hardware, software and operations.

Security

- Increase the overall IT security posture of the government.

Investments

- Shift IT investments to more efficient computing platforms and technologies.

Examples of Sustainable Data Centers

1. NCAR Wyoming Supercomputer Center
University Corporation for Atmospheric Research

2. ADC Green 1 McClellan Data Center

3. EDS Wynyard Data Center

1. National Corporation for Atmospheric Research

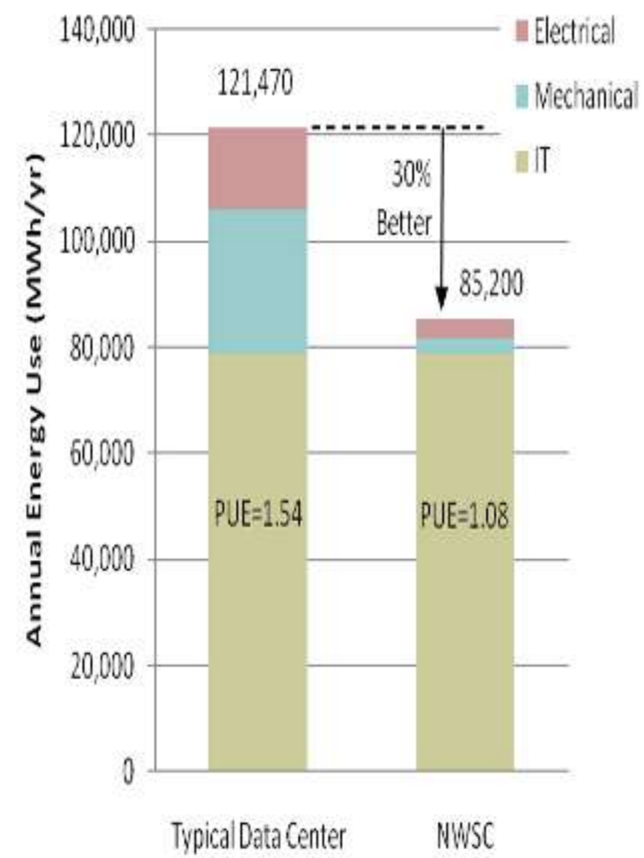
Cheyenne, Wyoming

196,000 gsf PUE 1.08

• two 98,000-square-foot modules
•raised-floor spaces of approximately 15,000 sq-ft
• 6,000 square feet of data storage and archival space
• a network operations center
•and 10,000 square feet of office space.

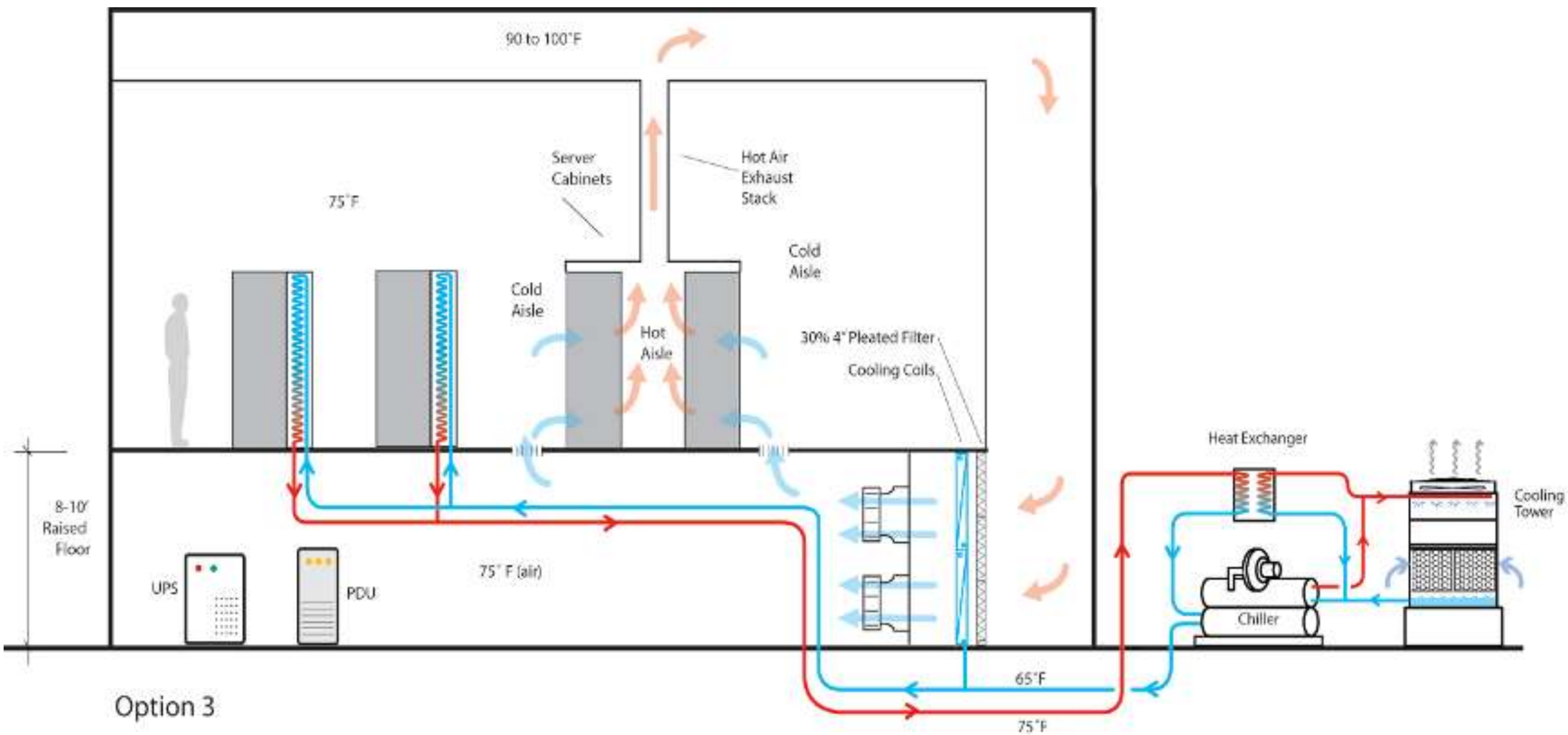
energy efficient design strategies

•Compressor-Free Cooling in Data Rooms
•High-Efficiency Cooling Plant
•High-Efficiency Fan Systems
•Variable speed primary-only pumping for hydronic distribution loops reduces pumping energy
•Low pressure drop design reduces fan and pump energy



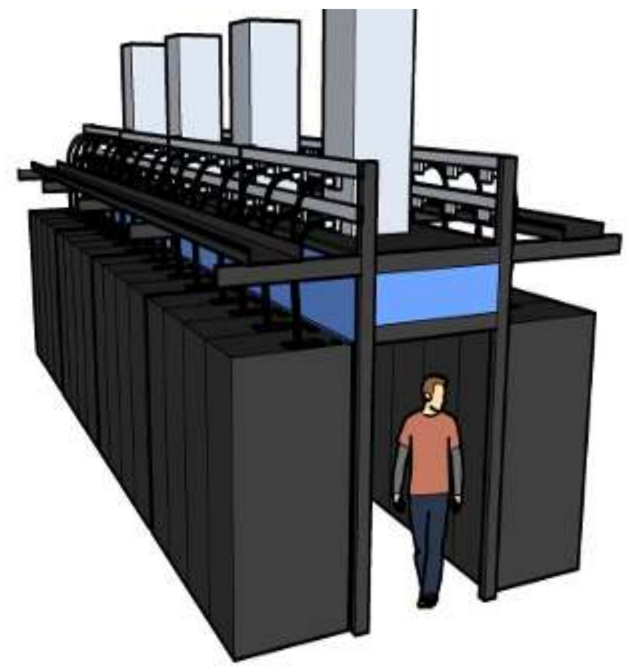
Office of Research Facilities

Compressor-free cooling used 96% of the year.
***65°F water**, limits chiller operation to only 200-500 hrs/yr.*
*Air-cooled, **75°F supply air** with hot-aisle containment allows “medium temperature” chilled water to be used.*



ADC Green 1 McClellan Data Center
Sacramento, California
156,600 gsf PUE 1.10

- 20 megawatt, highly energy efficient facility
- Annual energy savings for this project are projected to be in the neighborhood of 21%, or $2,150,000.
- Mechanical system will result in a reduction of cooling energy use compared to a typical data center of approximately 73%.



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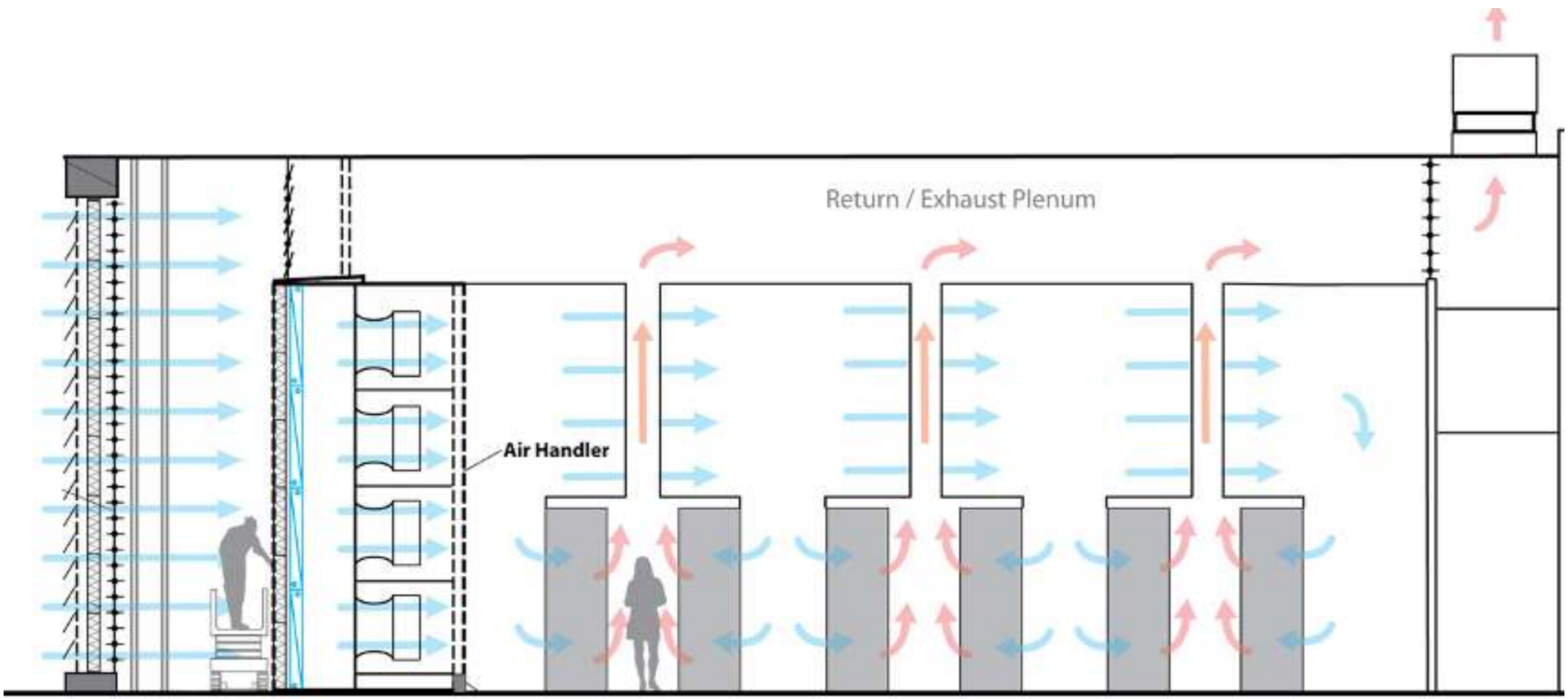
ADC Green 1 McClellan Data Center

- Mechanical strategies
  1. the air side economizer,
  2. a high-efficiency chiller plant,
  3. and high-efficiency fan systems.
- Electrical system features
  1. 97% efficient Hitec flywheel generators;
  2. Powersmiths e-Saver power distributors, which are 50% more efficient when partly loaded (at a 40% load) compared to double conversion battery UPSs and standard efficiency PDUs;
  3. “loop” electrical feeds with automatic transfer switches for redundant 2N distribution design.

ADC Green 1 McClellan Data Center

Energy savings realized from building-integrated outside air economizer system.
Airside design utilizes free cooling in a wide range of temperatures.
Full airside economizing operates at temperatures up to 70°F, and partial economizing is in operation between 70°F and 95°F OSAT.

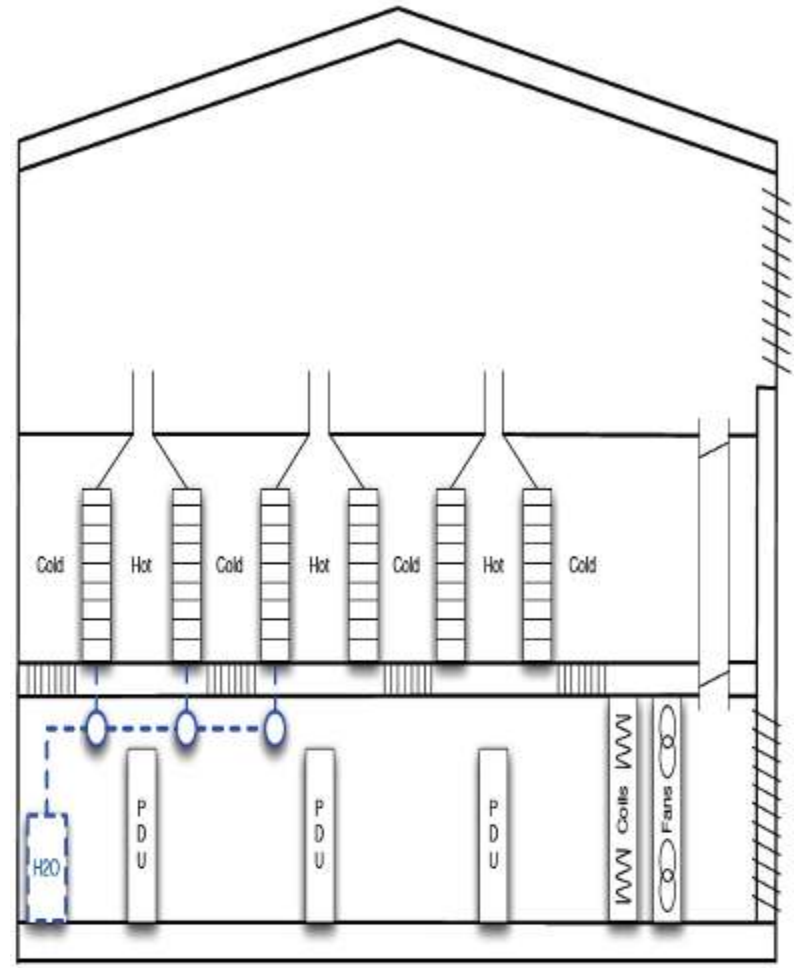


3. EDS Wynyard Data Center UK

100,000 gsf   PUE 1.17

Features & Strategies

- Replaced entry level servers with best-in-energy-class equipment
- Replaced static UPS system with a rotary hybrid system
- Eliminated chillers using outside air economizer system with backup direct evaporative cooling.
- Raised floor - mezzanine deck as the supporting structure for the IT equipment, potential for a future liquid cooling system;
- Used supply and return air plenums instead of ducts;
- Enclosed hot aisles



Sustainable Data Centers - Summary

- Meter and monitor PUE-Total Data Center + IT Equip
- Improve Data Center Infrastructure
  - Cool what needs to be cooled (the servers)
  - Minimize unnecessary requirements
- Focus on using servers wisely (40-60% utilization capacity)
  - Minimize unnecessary requirements

Questions?

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Office of Research Facilities

Backup Slides

Sustainable Data Centers: Average Use

- **The Average Data Center has a Power Usage Effectiveness (PUE) of 1.91**

PUE (Power Usage Effectiveness)

- (Power Entering Data Center)/(Power Used to run computer infrastructure)
  - improves as you get closer to 1

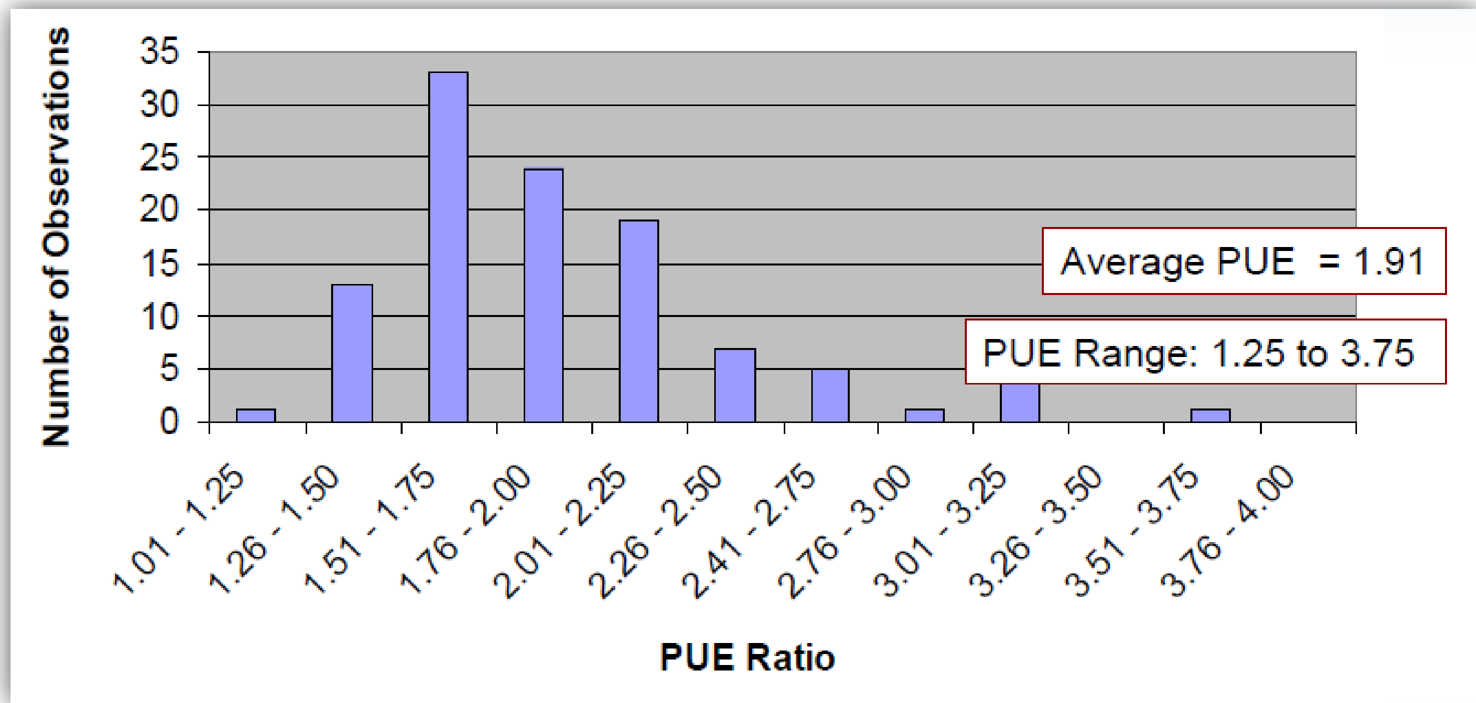


Fig 4.1. – Average Data Center PUE

Sustainable Data Centers: IT equipment load intensity

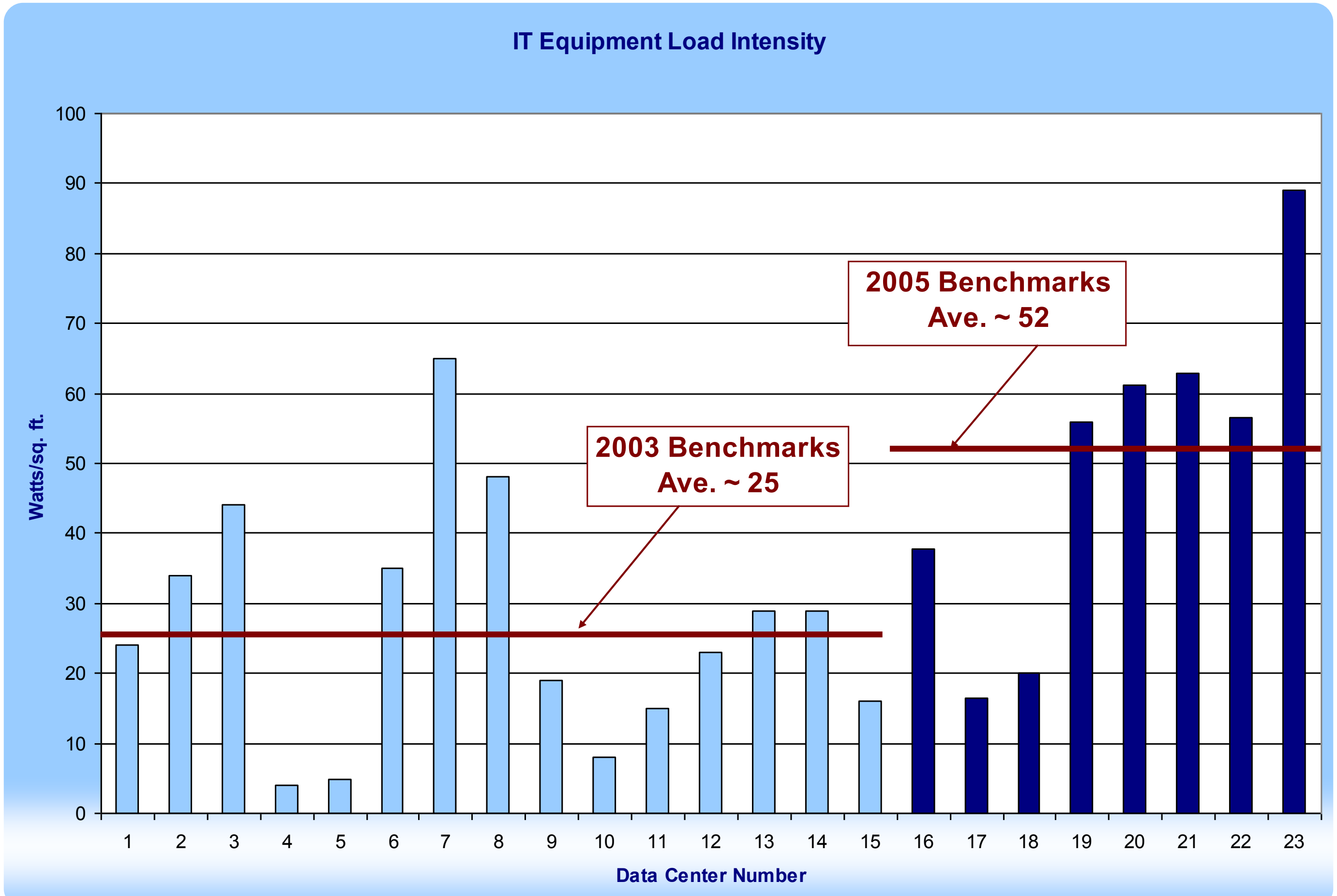


Fig 5.1. – Average IT Equipment Load Intensity

As server processes become more demanding, so does the demand on energy needs…

There has been a 50% increase in Watts/sq.ft. in 2 years!

The standard ―business as usual" strategies for server design and cooling that use to work, can no longer keep up with the upgraded capabilities of newer equipment!

Sustainable Data Centers: Reference

Design conditions at the zone

Table 2.1
Class 1, Class 2 and NEBS Design Conditions

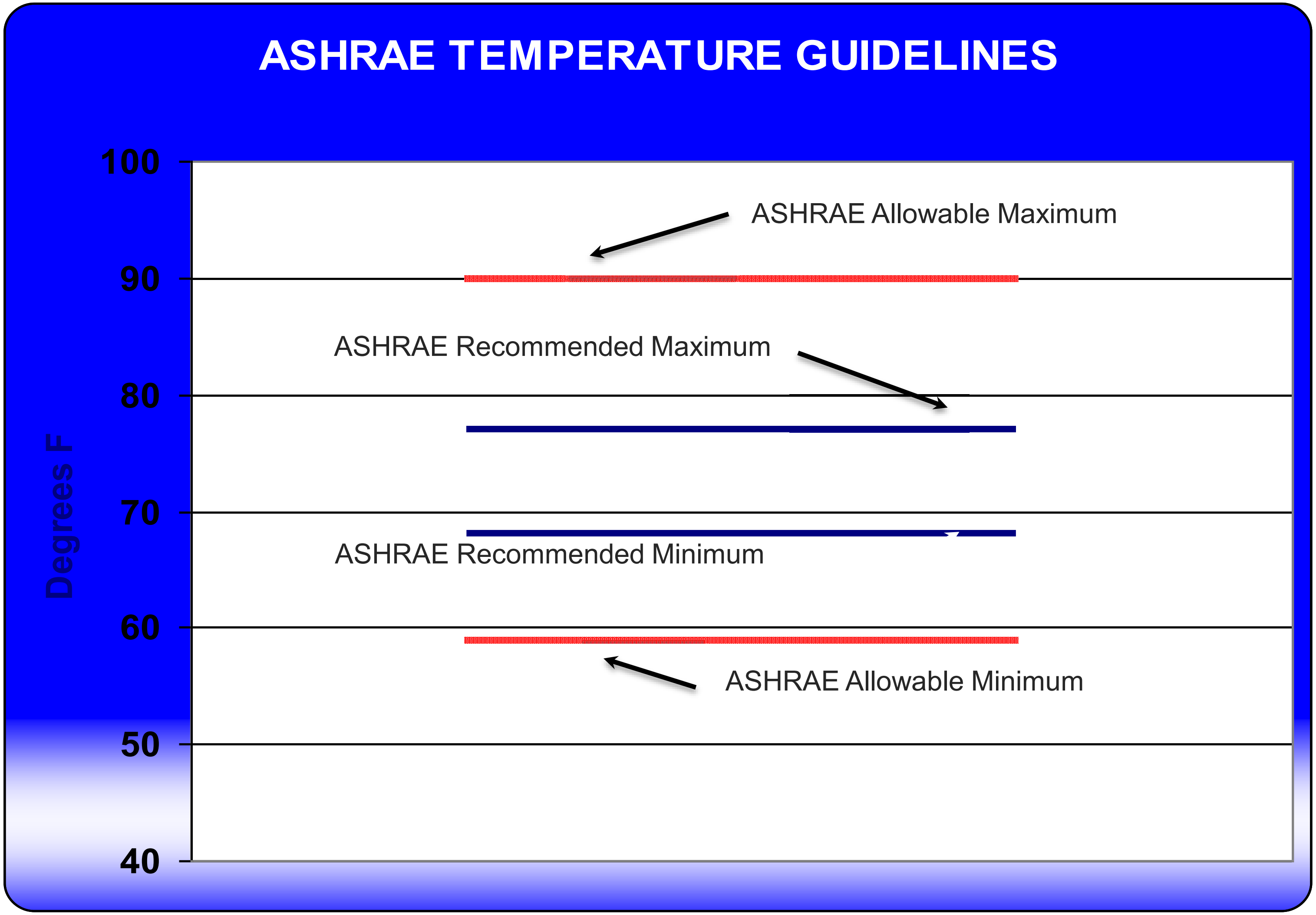
Condition	Class 1 / Class 2		NEBS	
	Allowable Level	Recommended Level	Allowable Level	Recommended Level
Temperature control range	59°F – 90°F[a,f] (Class 1) 50°F – 95°F[a,f] (Class 2)	68°F – 77°F[a]	41°F – 104°F[c,f]	65°F – 80°F[d]
Maximum temperature rate of change	9°F. per hour[a]		2.9°F/min.[d]	
Relative humidity control range	20% - 80% 63°F. Max Dewpoint[a] (Class 1) 70°F. Max Dewpoint[a] (Class 2)	40% - 55%[a]	5% to 85% 82°F Max Dewpoint[c]	Max 55%[e]
Filtration quality	65%, min. 30%[b] (MERV 11, min. MERV 8)[b]			

[a] These conditions are inlet conditions recommended in the ASHRAE Publication *Thermal Guidelines for Data Processing Environments* (ASHRAE, 2004).
[b] Percentage values per ASHRAE *Standard* 52.1 dust-spot efficiency test. MERV values per ASHRAE Standard 52.2. Refer to Table 8.4 of this publication for the correspondence between MERV, ASHRAE 52.1 & ASHRAE 52.2 Filtration Standards.
[c] Telecordia 2002 GR-63-CORE
[d] Telecordia 2001 GR-3028-CORE
[e] Generally accepted telecom practice. Telecom central offices are not generally humidified, but grounding of personnel is common practice to reduce ESD.
[f] Refer to Figure 2.2 for temperature derating with altitude

2005, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (www.ashrae.org). For Network Equipment Building System.

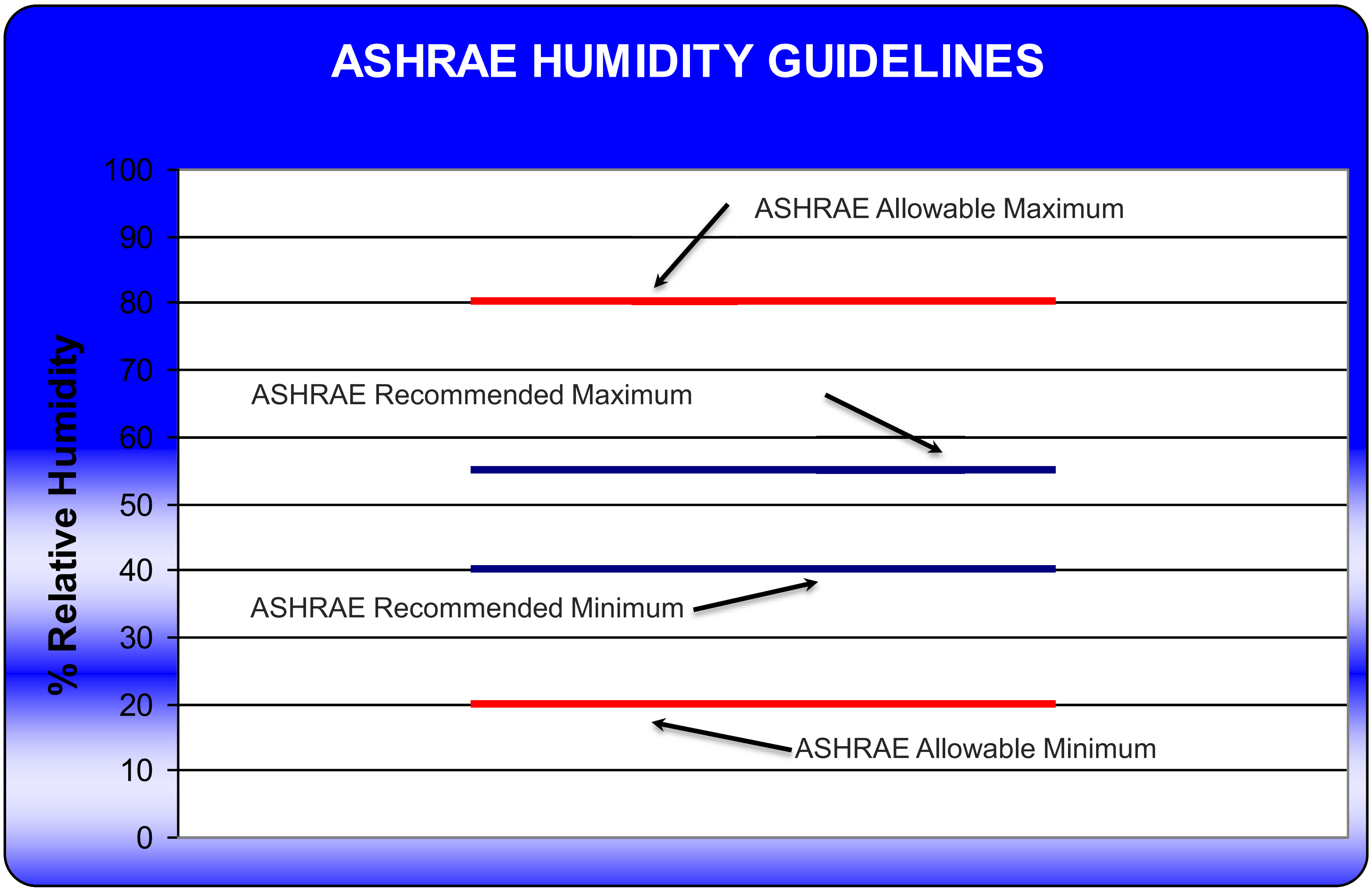
Sustainable Data Centers: Reference

Temperature Guidelines – at The Inlet to IT Equipment



Sustainable Data Centers: Reference

Humidity Guidelines — at The Inlet to IT Equipment



Sustainable Data Centers: Background

How much power do data centers really use?

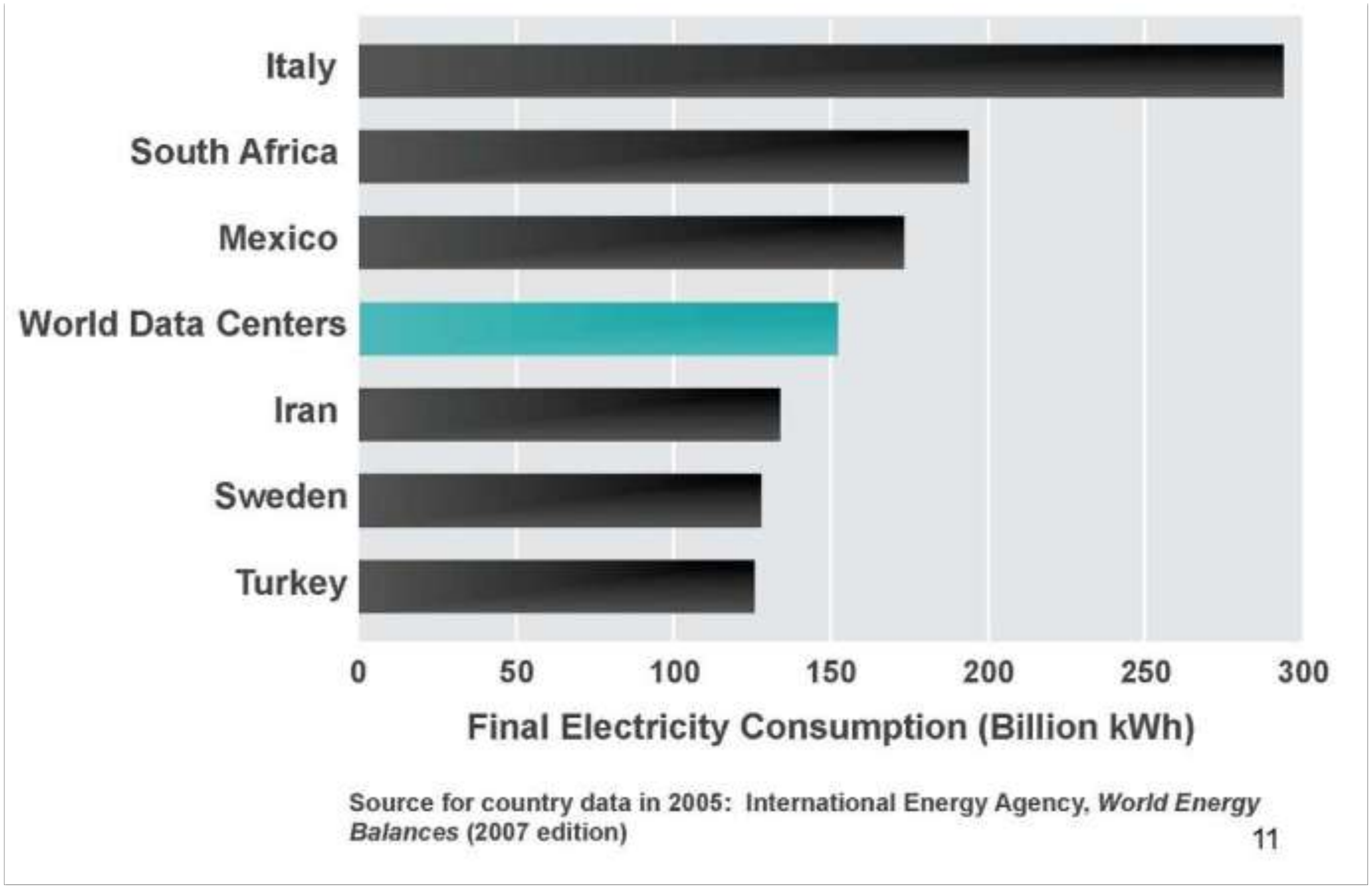


Fig 3.1. - Traditional Data Center Power Consumption

Sustainable Data Centers: Data Center Power

TOTAL FACILITY POWER. This includes everything that supports the IT equipment load.

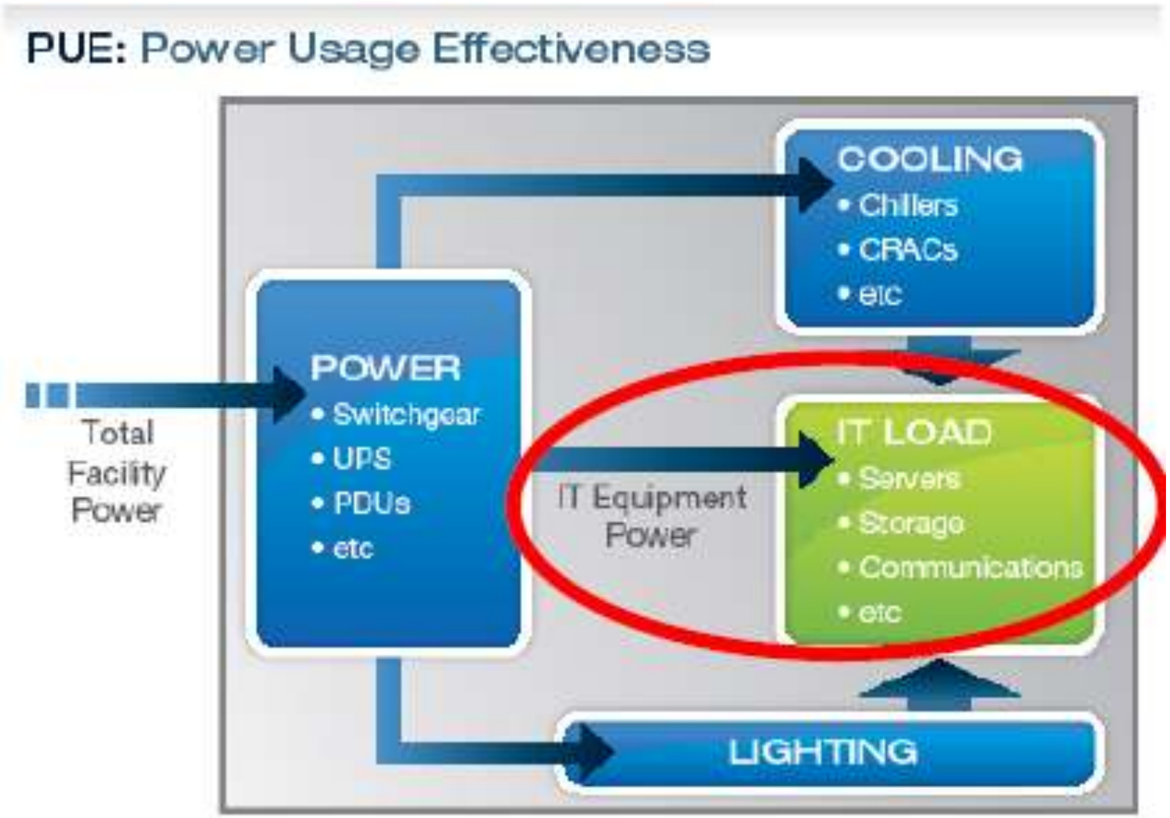


Fig 7.1. – PUE Breakdown

The Power Usage Effectiveness (PUE) is defined as follows:

PUE = Total Facility Power/IT Equipment Power

The reciprocal, the Datacenter Efficiency (DCiE) is defined as:

DCiE = 1/PUE = IT Equipment Power / Total Facility Power x 100%

Its not just cooling…The efficiency of use of your servers is critical as well!!!

Sustainable Data Centers Initiative: Cooling Systems

Traditional Aisle Containment

• In the cold aisles, the server racks are aligned so equipment inlets are facing each other on opposite sides.

• In the next aisle, both banks of server racks exhaust hot air.

• In the typical implementation, cool air from the Computer Room Air Conditioner (CRAC) or Computer Room Air Handler (CRAH) flows under a raised floor system, also called a plenum, to perforated floor tiles.

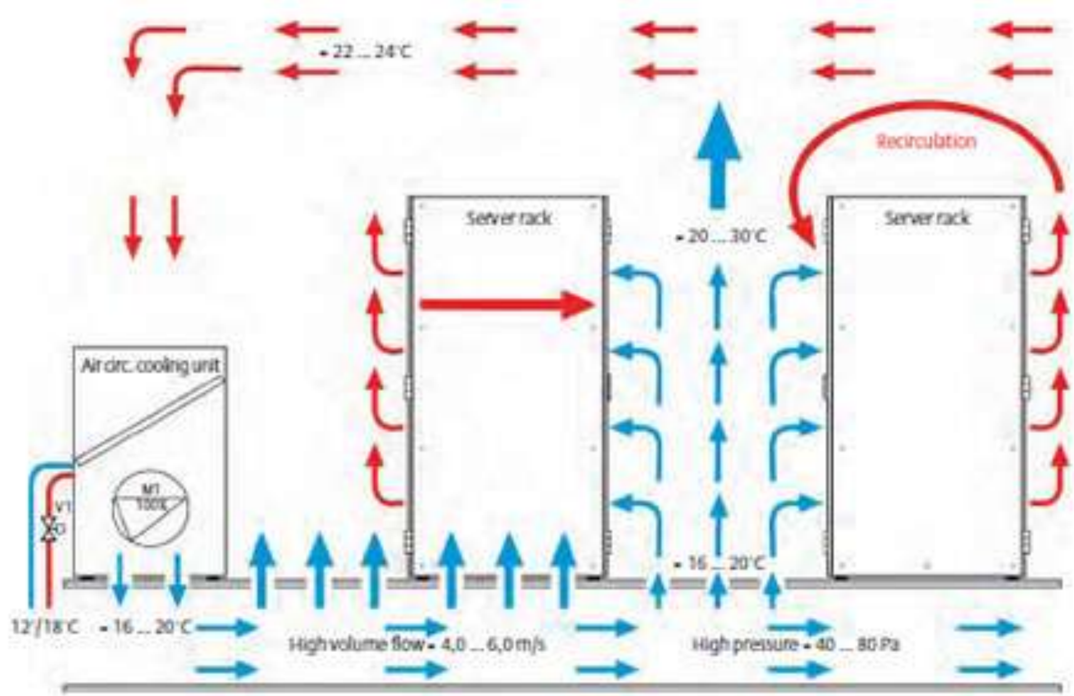


Fig 18.1. - **Diagram of a Data Center with Bypass Air problems (mixing of hot and cold air) - a very common cause of power loss.**

Challenges:

Bypass air-"the volume of cold supply air that enters the room but does not directly enter the IT equipment"-limits the precise delivery of cold air at the server intake.

Hot air recirculation, where exhaust heat enters the cold aisle, either over the tops of racks or through open rack spaces, ensures that the cooling infrastructure must throw colder air at the equipment to offset this mixing.

Hot air contamination prohibits the air handlers from receiving the warmest possible exhaust air, rendering their operation less efficient.

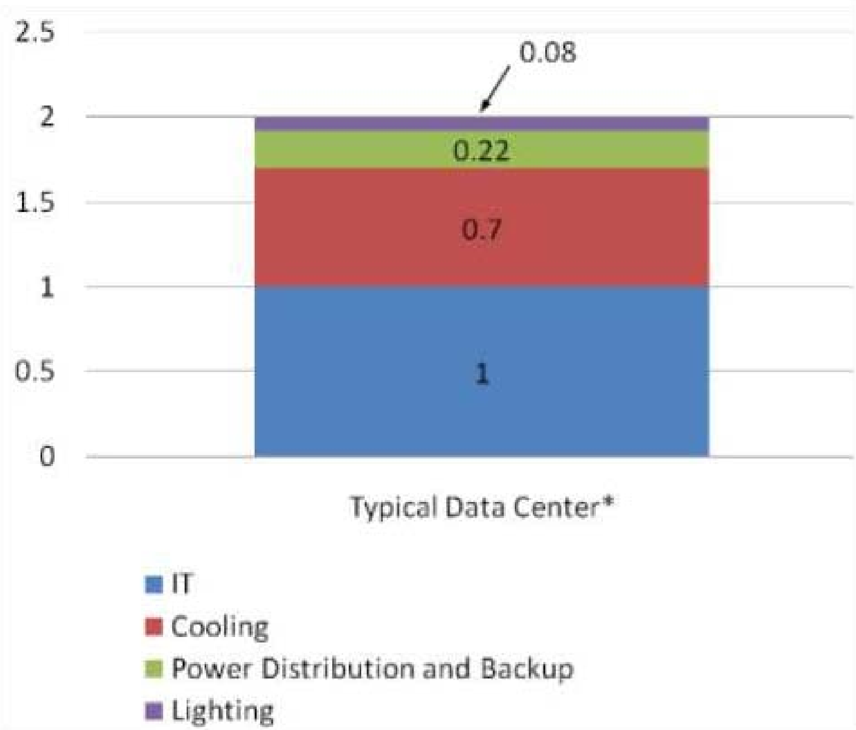
Hot spots may persist as a result of all of the above

Sustainable Data Centers: Data Center Power

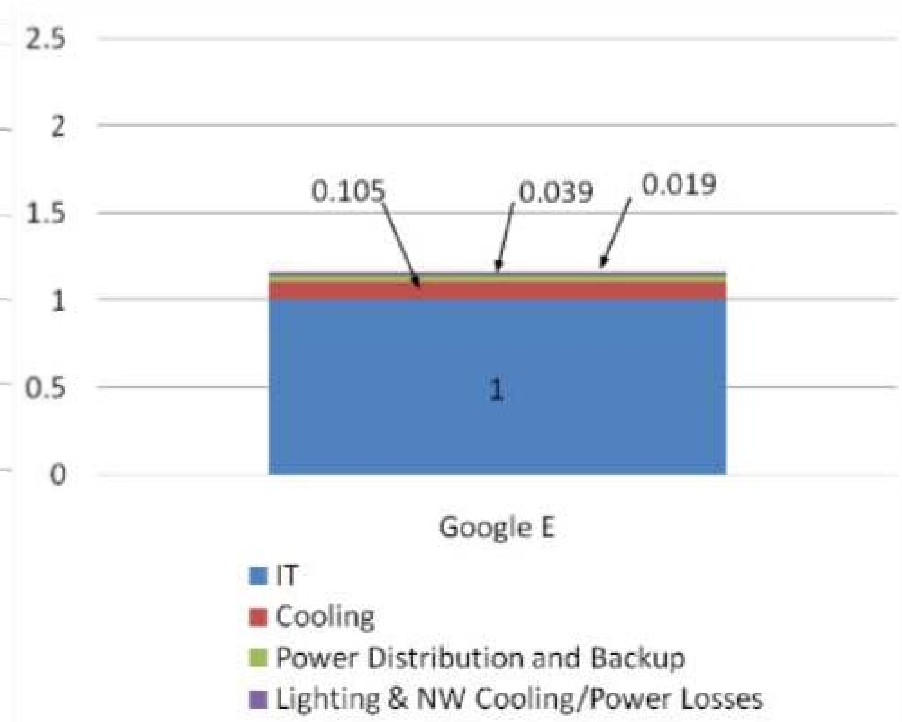
PUE Components: Typical vs. Google

Impact of power & cooling innovations and best practices

Typical PUE = 2.0



Google Data Center ‘E’ PUE = 1.16



*Reference: Silicon Valley Leadership Group, Data Center Energy Forecast, Final Report July, 2008
Google E Data Center energy-weighted average PUE results from Q2-Q1’09 (to 3/15/09)

Sustainable Data Centers Initiative: Cooling Systems

Cold Aisle Containment

The focus of cold aisle containment is to cool the IT equipment, not the whole room, with targeted cooling at the equipment inlet!

• As the name implies, cold aisle containment attempts to isolate the cold air in a "room" of its own.

• By using containment curtains, metal, or other similar barrier, the cooling air is concentrated at the equipment intake.

• Cold aisle containment produces a consistent temperature over the entire height of the cold aisle.

• Reduces the air speed intake, and the air temperature intake can be increased (20 - 25°C).

• The higher intake air temperature also allows the inflow water temperature to be increased, which results in further energy savings.

• Higher inflow temperatures provide more time for cooling through free cooling.

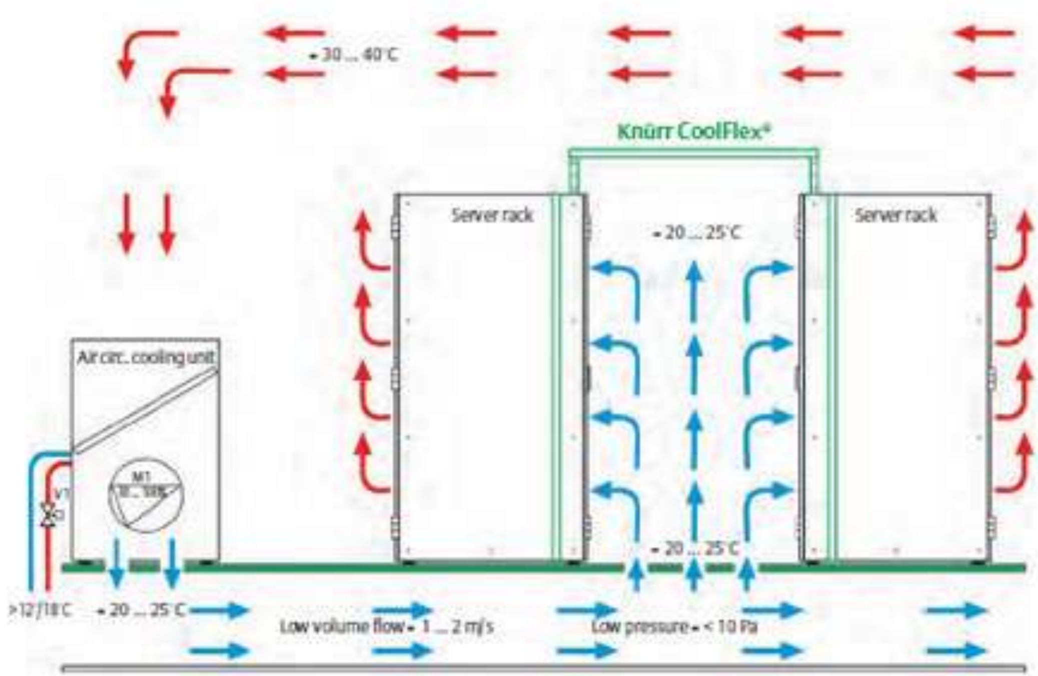


Fig 19.1. - **Diagram of a Data Center with example of enclosed cold aisle containment.**

Advantages

• lower energy costs for driving fans in the CRAC equipment,
• suitable air temperature intake for servers,
• more pleasant working conditions).

Sustainable Data Centers: Federal Data Center Consolidation

Data Center Consolidation Plan

1. INITIAL ASSET INVENTORY
2. INITIAL DATA CENTER CONSOLIDATION PLAN
3. FINAL ASSET INVENTORY BASELINE
4. FINAL DATA CENTER CONSOLIDATION PLANS
5. ONGOING MONITORING

Fig 24.1. – Green wall at Citi Data Center in Frankfurt German Data Center

Sustainable Data Centers: Data Center Power

True or False?

Cooling is the only area that can be economized in data centers to save energy?

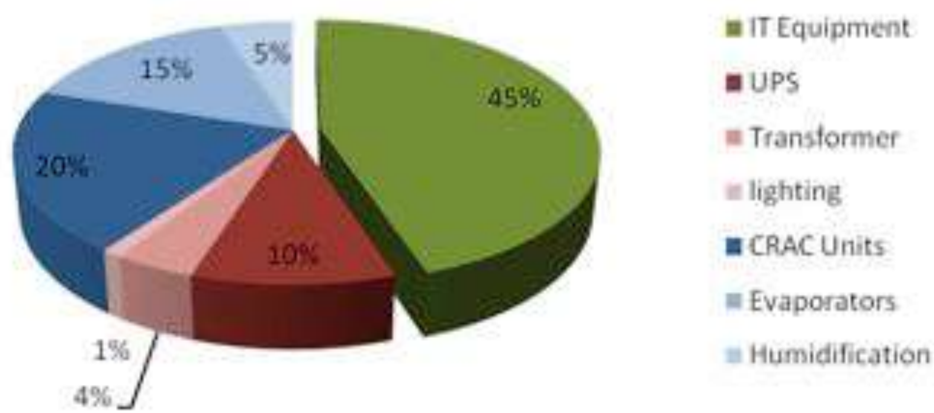


Fig 6.1. – Data Energy Use Pie Chart

False!

Approximately 40% - 60% of the power delivered to a data center will get delivered to IT equipment. This presents a large potential for savings in energy and efficiency as well!

Sustainable Data Centers: Power Delivery Components

Perform Simulations!!!

- The simulation provides complete information about temperatures, pressures, velocities, and air flow paths throughout the data centre, for the specified layout and operating conditions.

- This enables the designer/user to (for example):
  - Examine air inflow temperatures for the IT equipment – to ensure that they are within recommended limits.
  - Identify potential causes of malfunction – e.g. airflow blockages in floor void, poor airflow distribution though floor grilles, etc.
  - Investigate effect of alternative cooling arrangements within cabinets or within the data centre.
  - Investigate impact of cooling unit failure – to assess redundancy or check switchover to stand-by power.

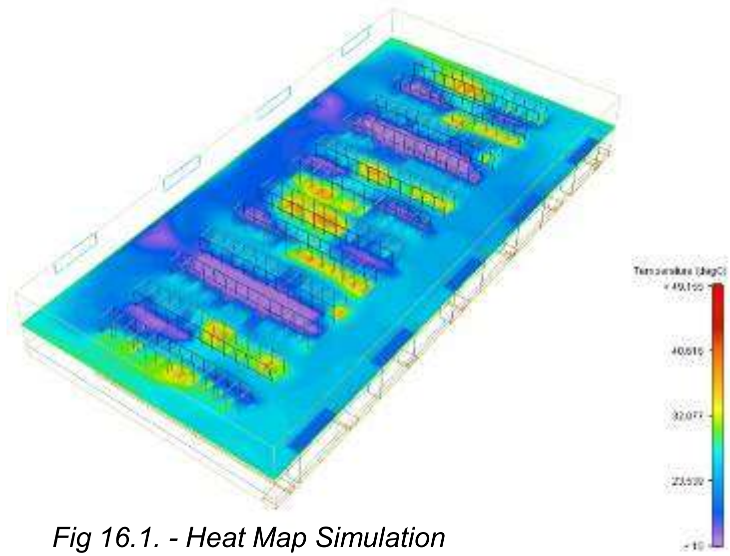


Fig 16.1. - Heat Map Simulation

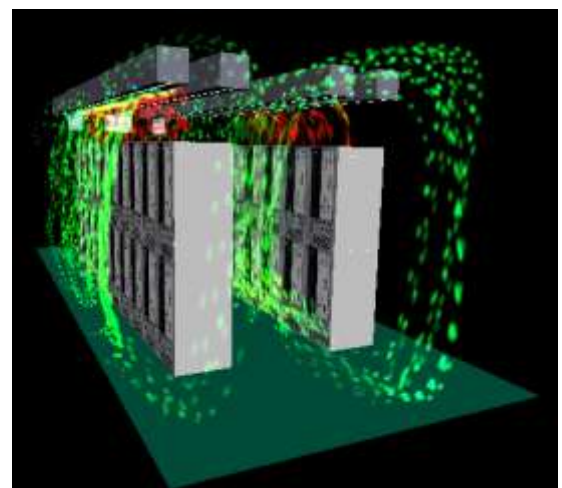


Fig 16.2. - Heat Flow Simulation

ITS ALWAYS CHEAPER TO FIX PROBLEMS IN THE VIRTUAL WORLD!!

NIH Data Center: Clinical Center

Unique Features & Strategies

- Double redundancy is required Tier 3 Data Center facility, most of the electrical equipment has redundancy.

- There are two (2) UPS rooms, each requiring
  - one (1) UPS (Un-interruptible Power Supply),
  - one (1) switchgear panel,
  - two (2) CRAC (Computer Room Air Conditioning)units
  - one (1) ATS (Automatic Transfer Switch).

NIH Data Center: Clinical Center

- 10 CRAC units - Six within the Data Center and 4 – 2 each – support the UPS rooms.
- The CRAC units run off of both normal and emergency power.
- The intent is that CRACs will run in failure to maintain minimum cooling loads.
- Condenser units support the CRAC units as do refrigerant and chilled Water.
- An Interstitial Space was created by installing standing seam roofing system indoors above the space.
- The servers are set up with under floor system cooling, aligned servers in open Cold Aisles
- The system is intended to provide protection to the Data Center from possible water/moisture leaks from an existing 8” storm line and existing lab waste piping that run above the space.