Government Information Technology Executive Council

Best Practices for Data Center Energy Efficiency

Washington DC

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

FEMP
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This Presentation is Available for download at:

http://datacenterworkshop.lbl.gov/

AGENDA

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- Introductions to course and instructors
- Performance metrics and benchmarking
- IT equipment and software efficiency
- Use IT to save IT (monitoring and dashboards)
- Data center environmental conditions
- Airflow management
- Cooling systems
- Electrical systems
- Summary and Takeaways

Challenging Conventional Wisdom: Game Changers

Conventional Approach

- Data centers need to be cool and controlled to tight humidity ranges
- Data centers need raised floors for cold air distribution
- Data centers require highly redundant building infrastructure

Need Holistic Approach

- IT and Facilities Partnership

Introduction

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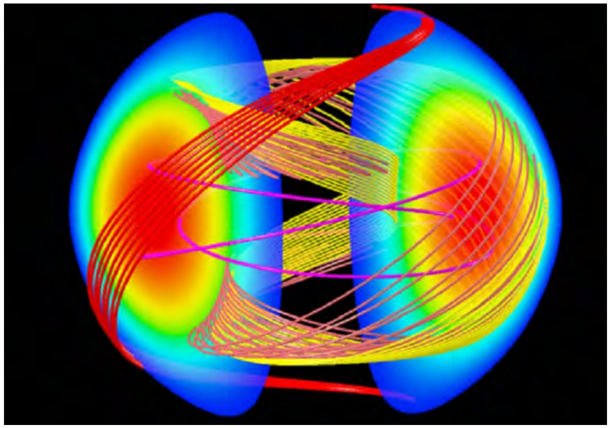
Data Center Energy

- Data centers are energy intensive facilities
  - 10 to 100 times more energy intensive than a office
  - Server racks now designed for more than 25+ kW
  - Surging demand for data storage
  - 1.5% of US Electricity consumption
  - Projected to double in next 5 years
  - Power and cooling constraints in existing facilities

LBNL operates large systems along with legacy systems



We also research energy efficiency opportunity and work on various deployment programs

LBNL Feels the Pain!

LBNL Super Computer Systems Power

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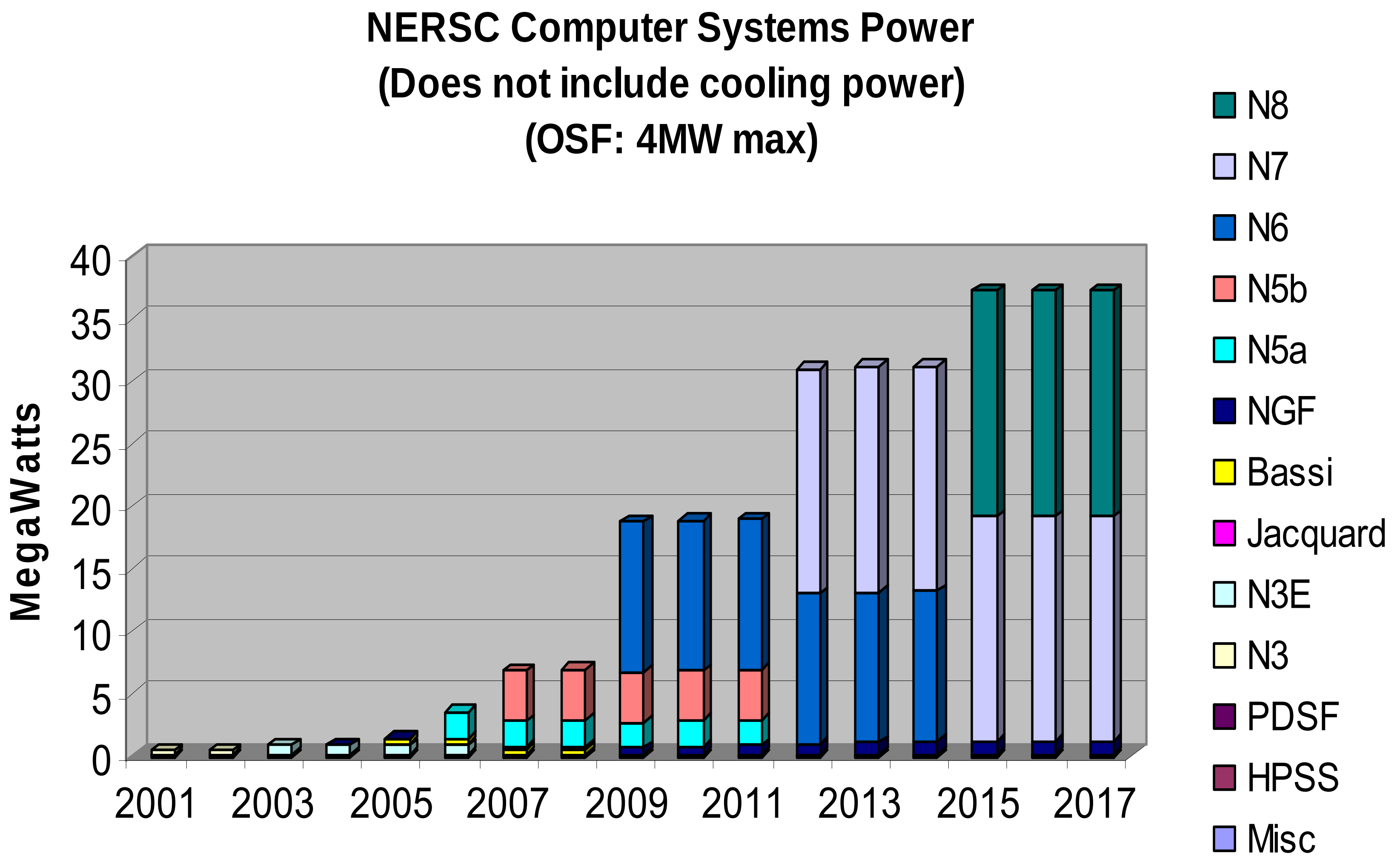

Data Center Energy Efficiency = 15% (or less)

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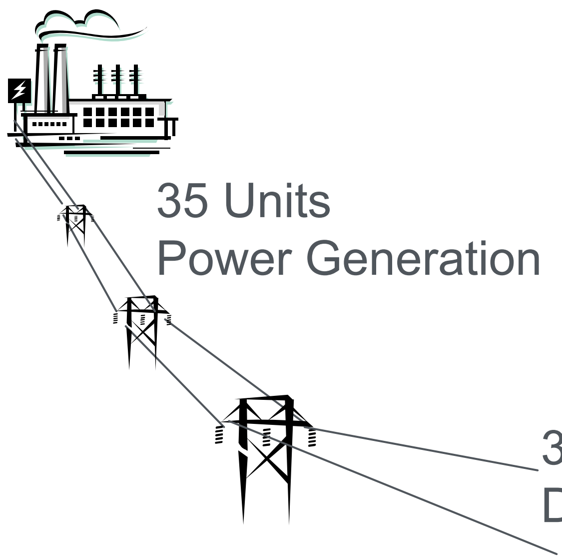
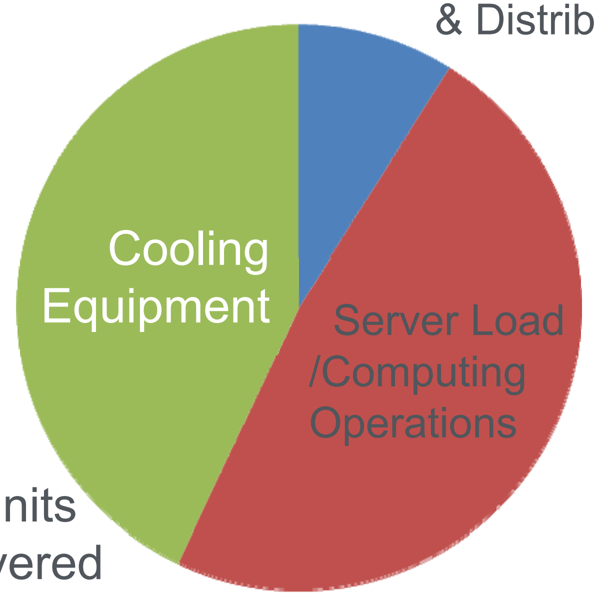
Energy Efficiency = Useful computation / Total Source Energy

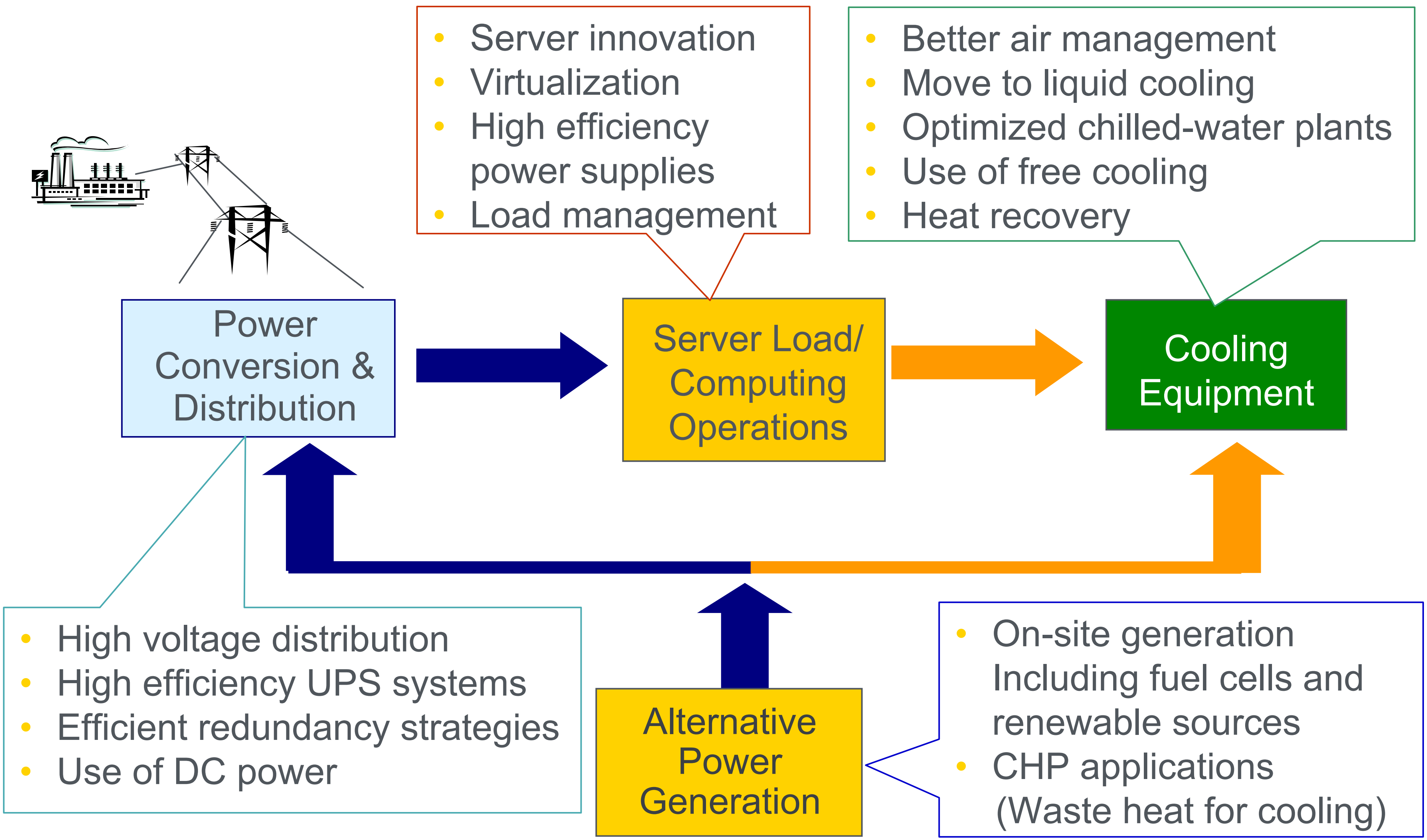
Typical Data Center Energy End Use

100 Units Source Energy





Energy Efficiency Opportunities



Potential Benefits of Data Center Energy Efficiency

- 20-40% savings typical
- Aggressive strategies can yield 50+% savings
- Extend life and capacity of infrastructures
- But is mine good or bad?

Performance metrics and benchmarking

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Benchmarking for Energy Performance Improvement:

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- Energy benchmarking can allow comparison to peers and help identify best practices
- LBNL conducted studies of over 30 data centers:
  - Wide variation in performance
  - Identified best practices
- Can't manage what isn't measured

Your Mileage Will Vary

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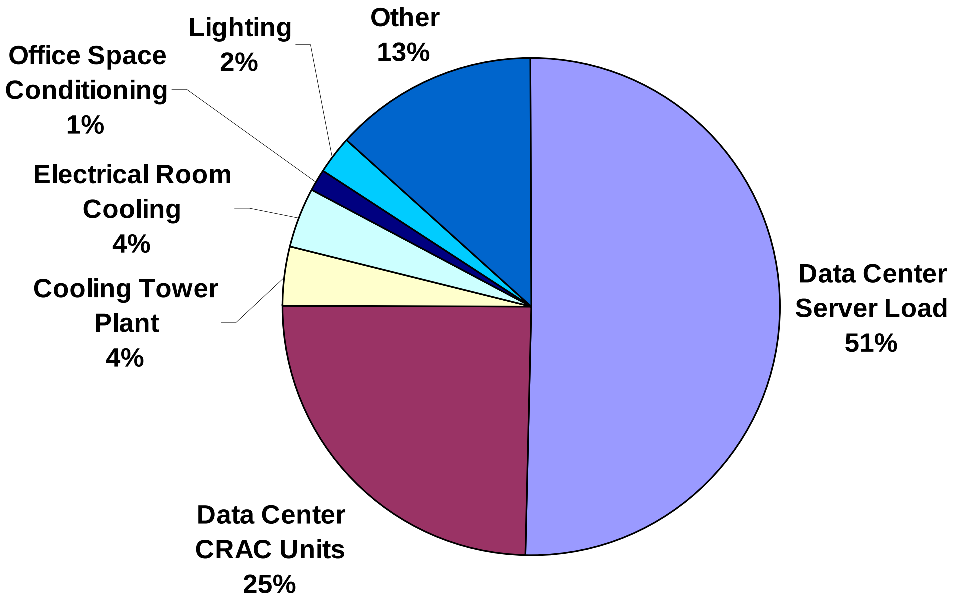
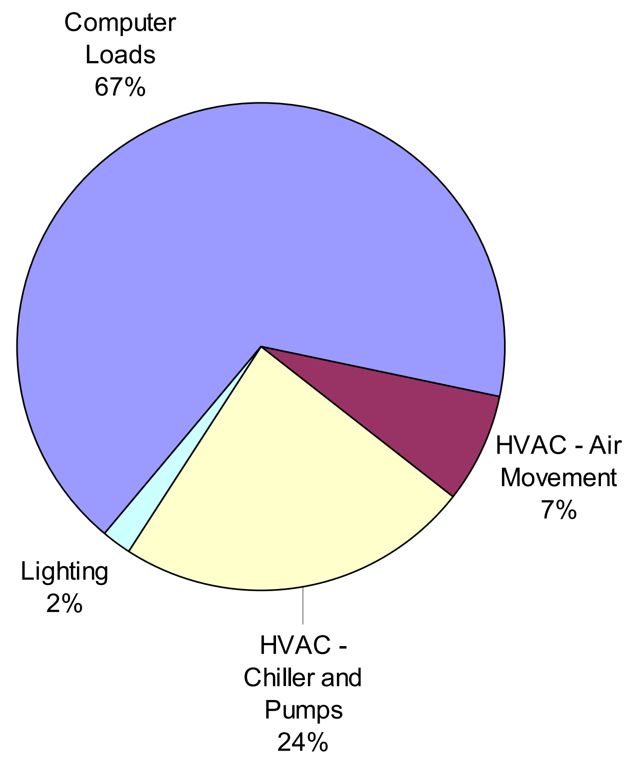
The relative percentages of the energy doing computing varies considerably.





Benchmarks obtained by LBNL

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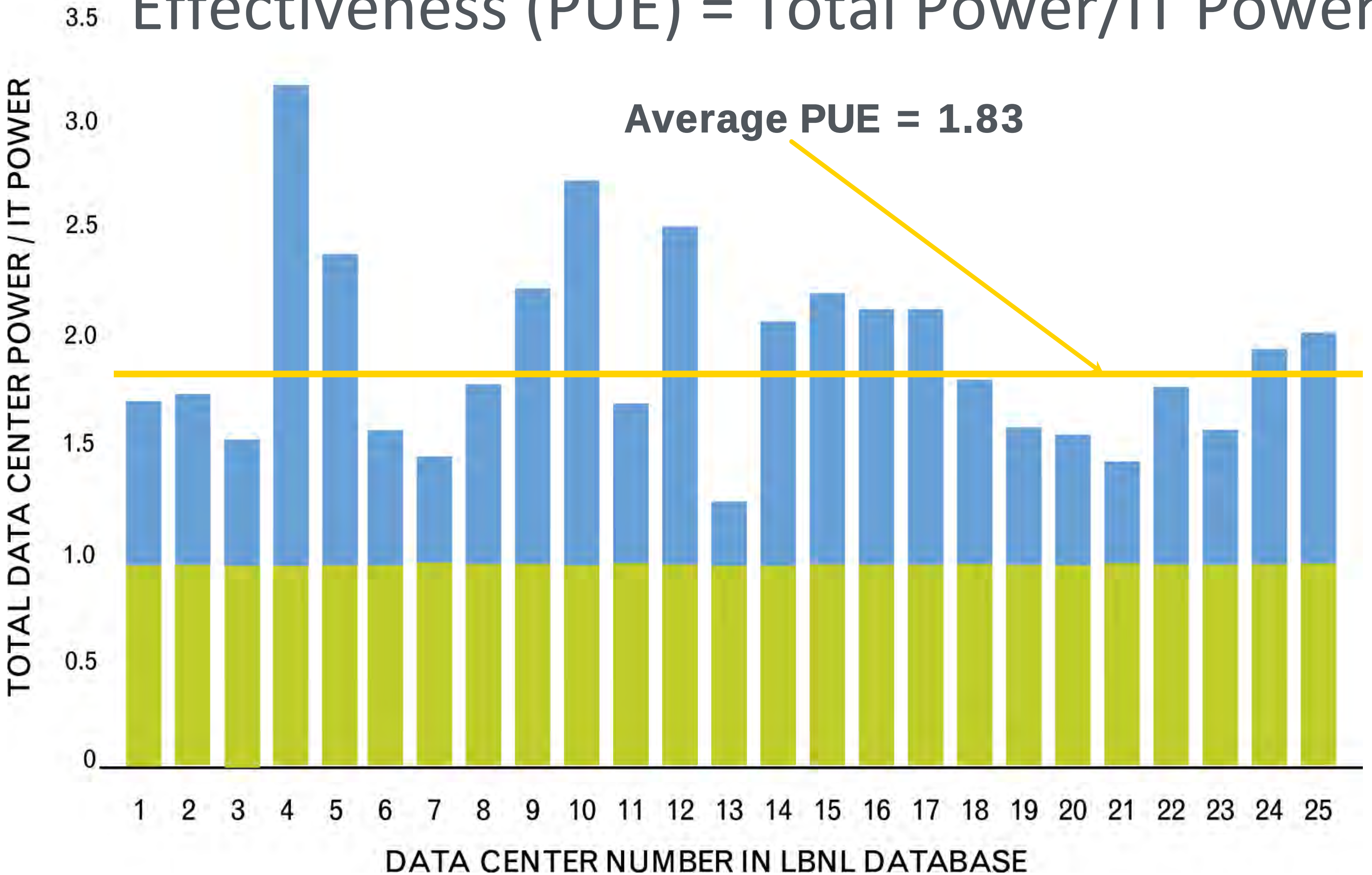
High Level Metric: Power Utilization Effectiveness (PUE) = Total Power/IT Power



You Can’t Manage What You Don’t Measure

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The private sector has a better handle on data center efficiency metrics

What Do They Know*?

	Private sector*	Public sector
PUE?	82%	23%
Average load?	94%	31%
Average server power density?	95%	29%

% of respondents who can provide data on these metrics for their organizations.
MeriTalk Study released June 2011

IT Equipment and Software Efficiency

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IT server performance - saving a watt…

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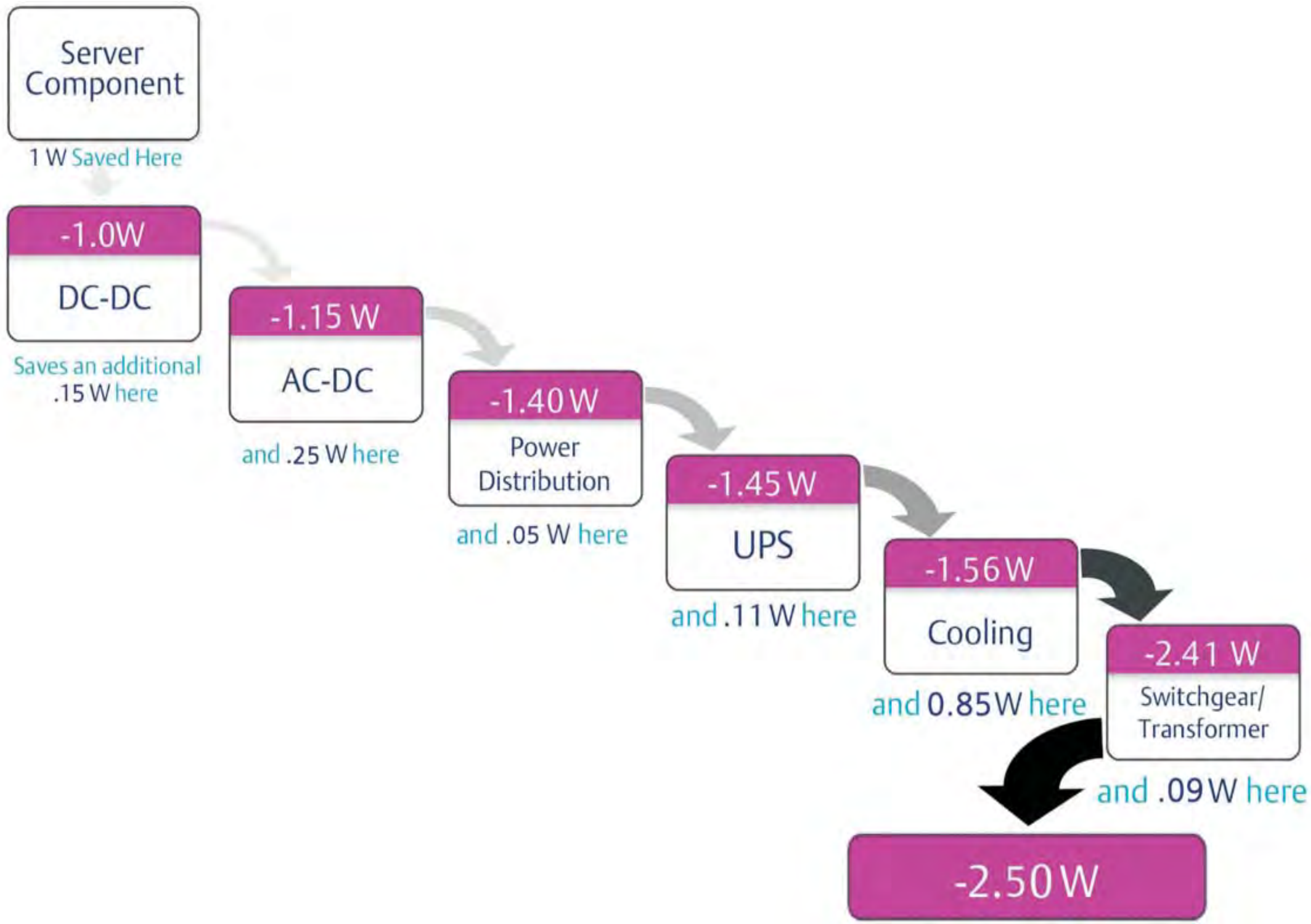
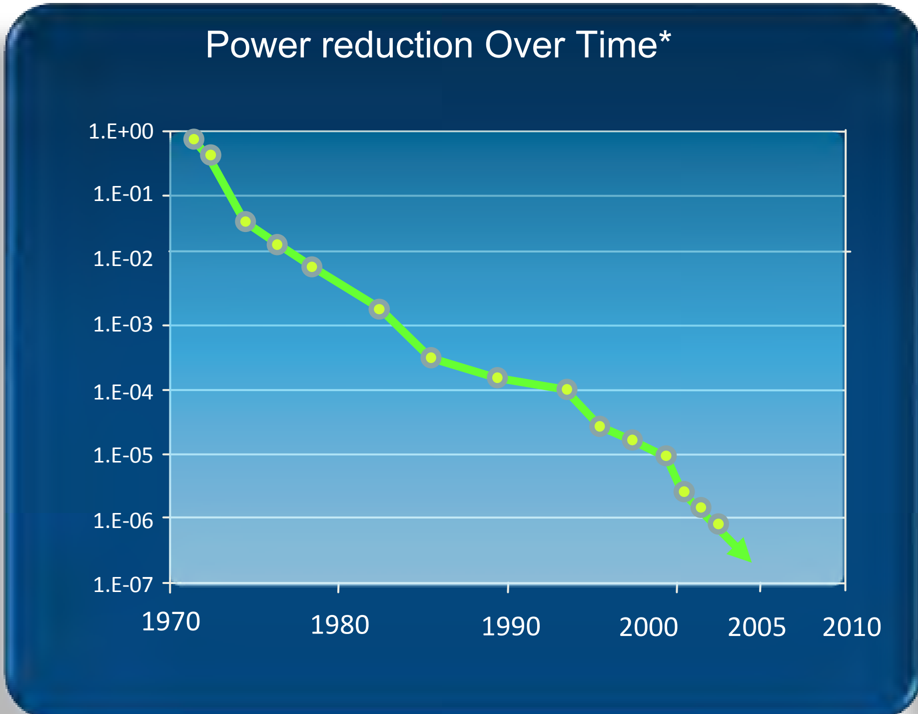
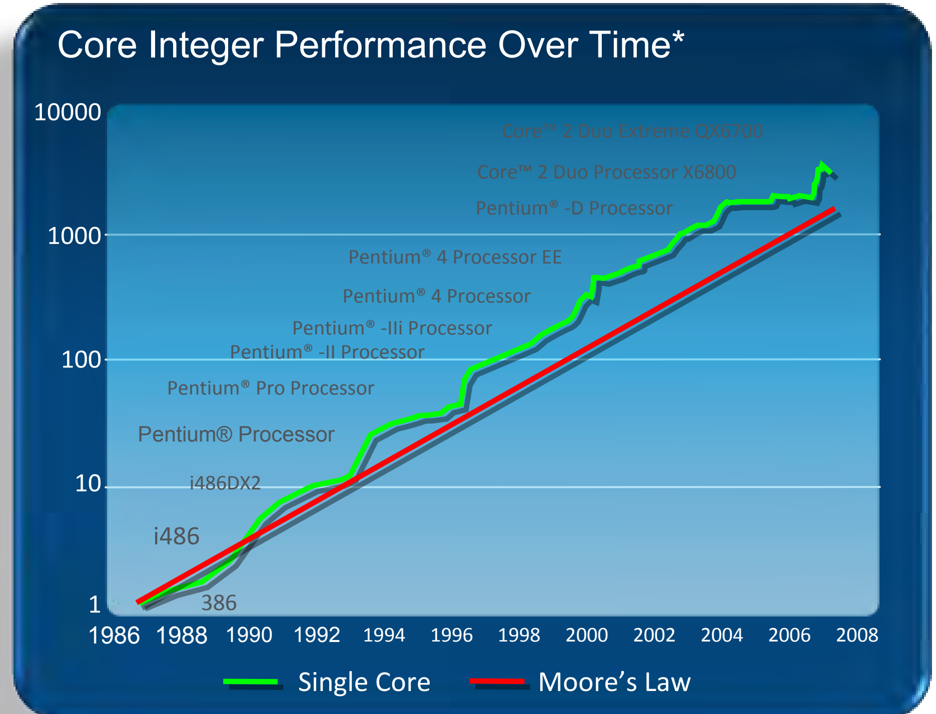
The value of one watt saved at the IT equipment



Moore’s Law





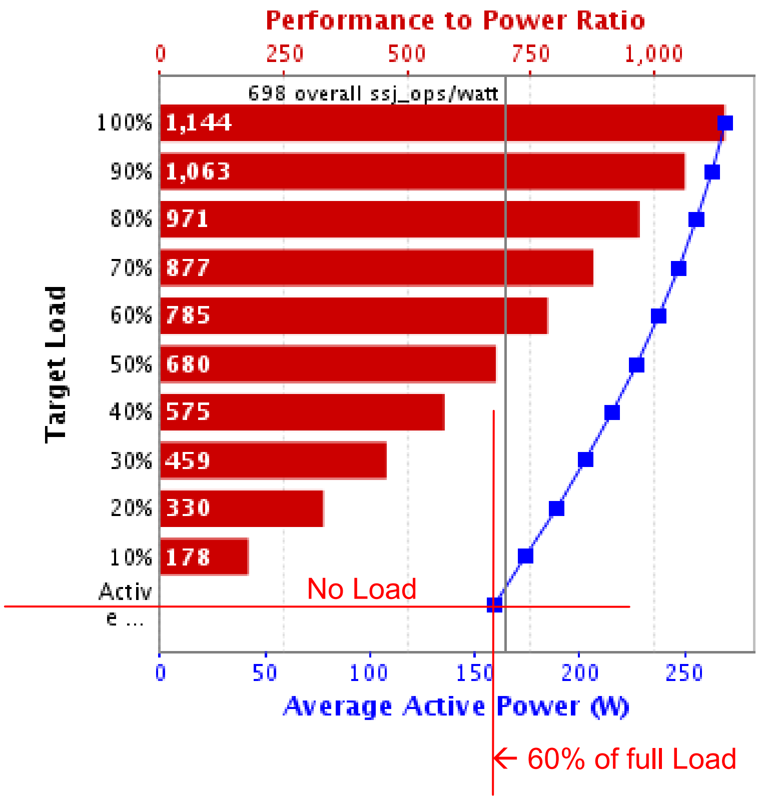
- Every year Moore’s Law is followed, smaller, more energy-efficient transistors result.
- Miniaturization provides 1 million times reduction in energy/transistor size over 30+ years.
- Benefits: Smaller, faster transistors => faster AND more energy-efficient chips.

Source: Intel Corp.

IT Energy Use Patterns: Servers

Idle servers consume as much as 50-60% of power @ full load as shown in SpecPower Benchmarks.

Performance			Power	
Target Load	Actual Load	ssj_ops	Average Active Power (W)	Performance to Power Ratio
100%	99.2%	308,022	269	1,144
90%	90.2%	280,134	264	1,063
80%	80.0%	248,304	256	971
70%	69.9%	217,096	247	877
60%	60.1%	186,594	238	785
50%	49.6%	154,075	227	680
40%	39.9%	123,805	215	575
30%	29.9%	92,944	203	459
20%	20.1%	62,364	189	330
10%	10.0%	31,049	174	178
Active Idle		0	160	0
Σ ssj_ops / Σ power =				698



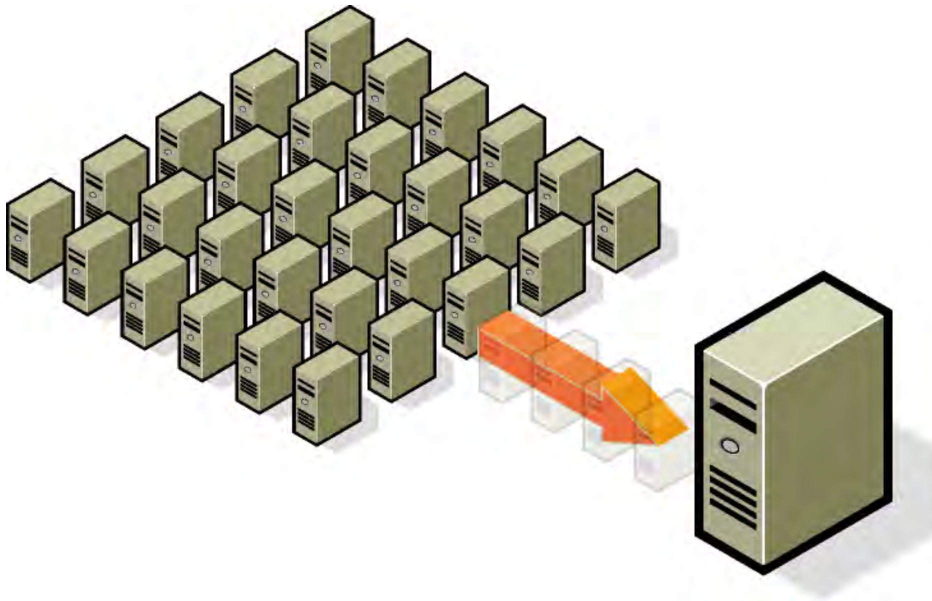
Decommission Unused Servers

PHYSICALLY RETIRE AN INEFFICIENT OR UNUSED SYSTEM

- **Uptime Institute reported 15-30% of servers are on but not being used**
- **Decommissioning goals include:**
  - Regularly inventory and monitor
  - Consolidate/retire poorly utilized hardware

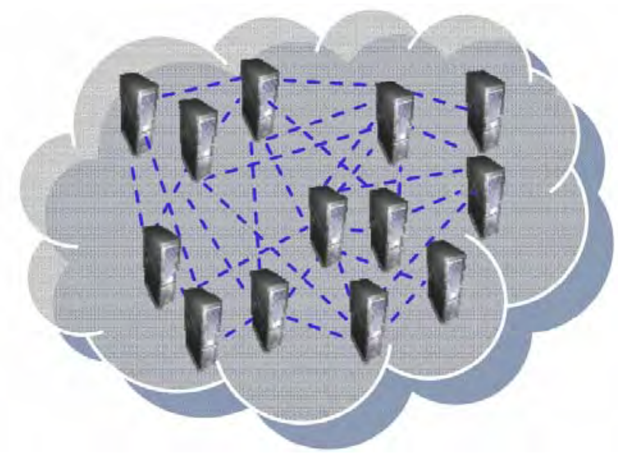
Virtualize and Consolidate Servers and Storage

- Run many "virtual" machines on a single "physical" machine
- Consolidate underutilized physical machines, increasing utilization
- Energy saved by shutting down underutilized machines

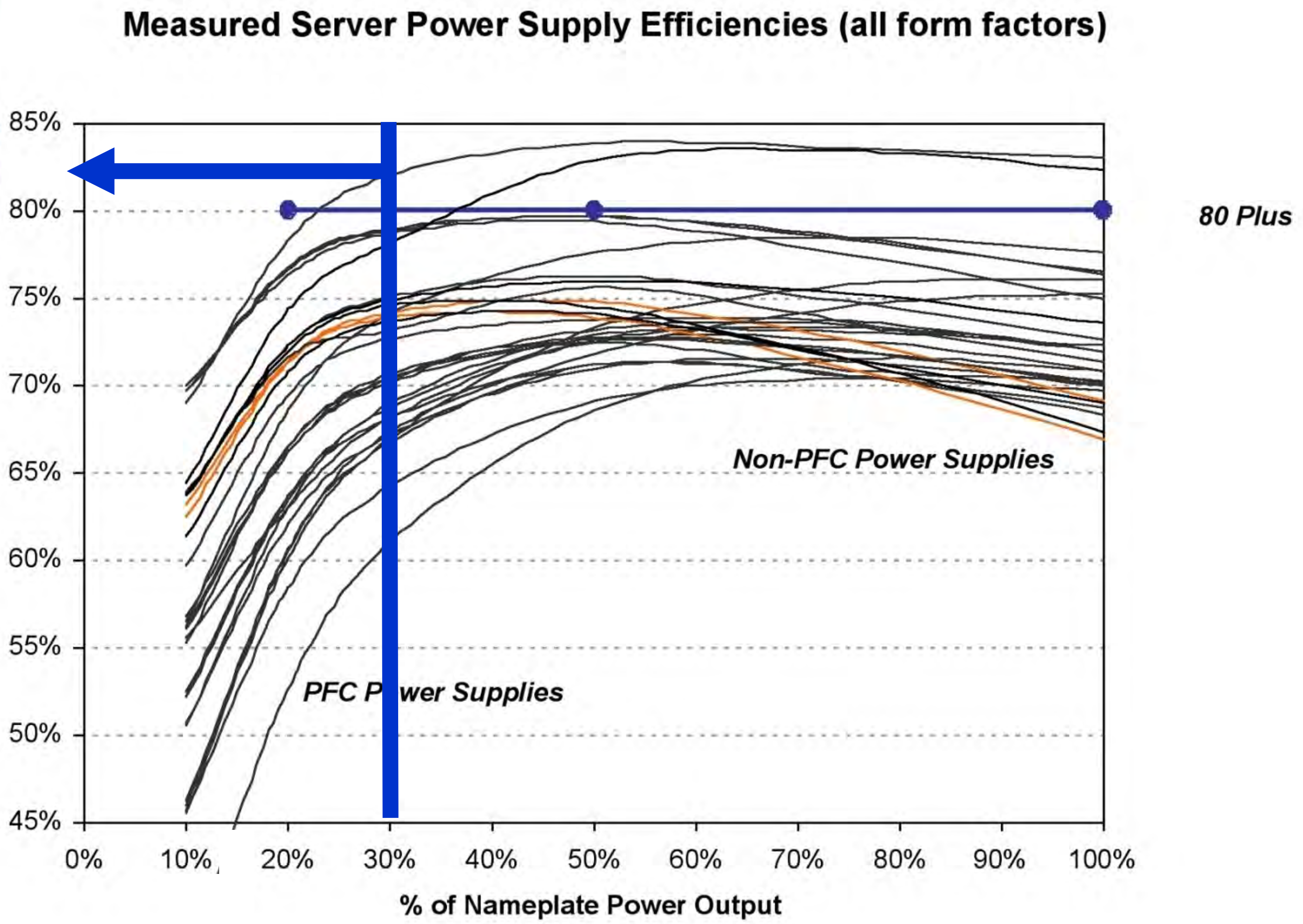


Vertualized cloud computing can provide…

- Dynamically scalable resources over the internet
- Can be internal or external
- Can balancing different application peak loads
- Typically achieves high utilization rates



LBNL/EPRI measured power supply efficiency



IT System Efficiency Summary…

Servers

- Enable *power management capabilities*!
- Use EnergyStar® Servers

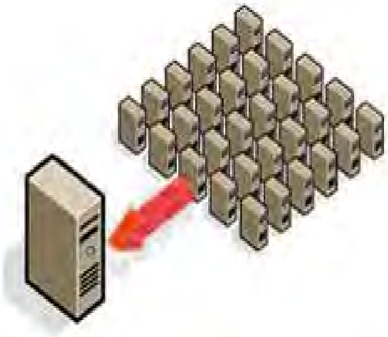
Power Supplies

- Reconsider Redundancy
- Spec 80 PLUS or Climate Savers products

Storage Devices

- Take superfluous data offline
- Use thin provisioning technology

Consolidation



- Use virtualization
- Consider cloud services

Using IT to Manage IT

Innovative Application of IT in Data Centers

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Using IT to Save Energy in IT:

- Most operators lack “visibility” into their data center environment
- An operator can’t manage what they don’t measure
- Goals:
  - Provide the same level of monitoring and visualization of the physical space that exists for monitoring the IT environment
  - Measure and track performance metrics
  - Spot problems before they result in high energy cost or down time

LBNL Wireless sensor installation

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- ✓ LBNL installed 800+ point sensor network.
- ✓ Measures:
  - Temperature
  - Humidity
  - Pressure (under floor)
  - Electrical power
- ✓ Presents real-time feedback and historic tracking
- ✓ Optimize air management and other tasks based on empirical data, not intuition.

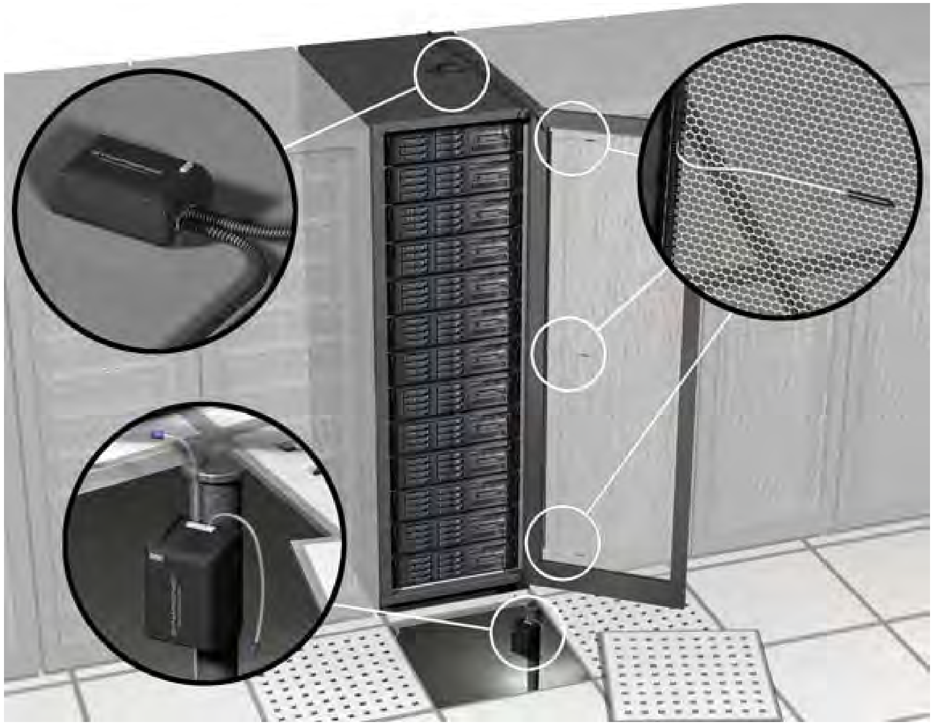

Image: SynapSense

Real-time temperature visualization by level

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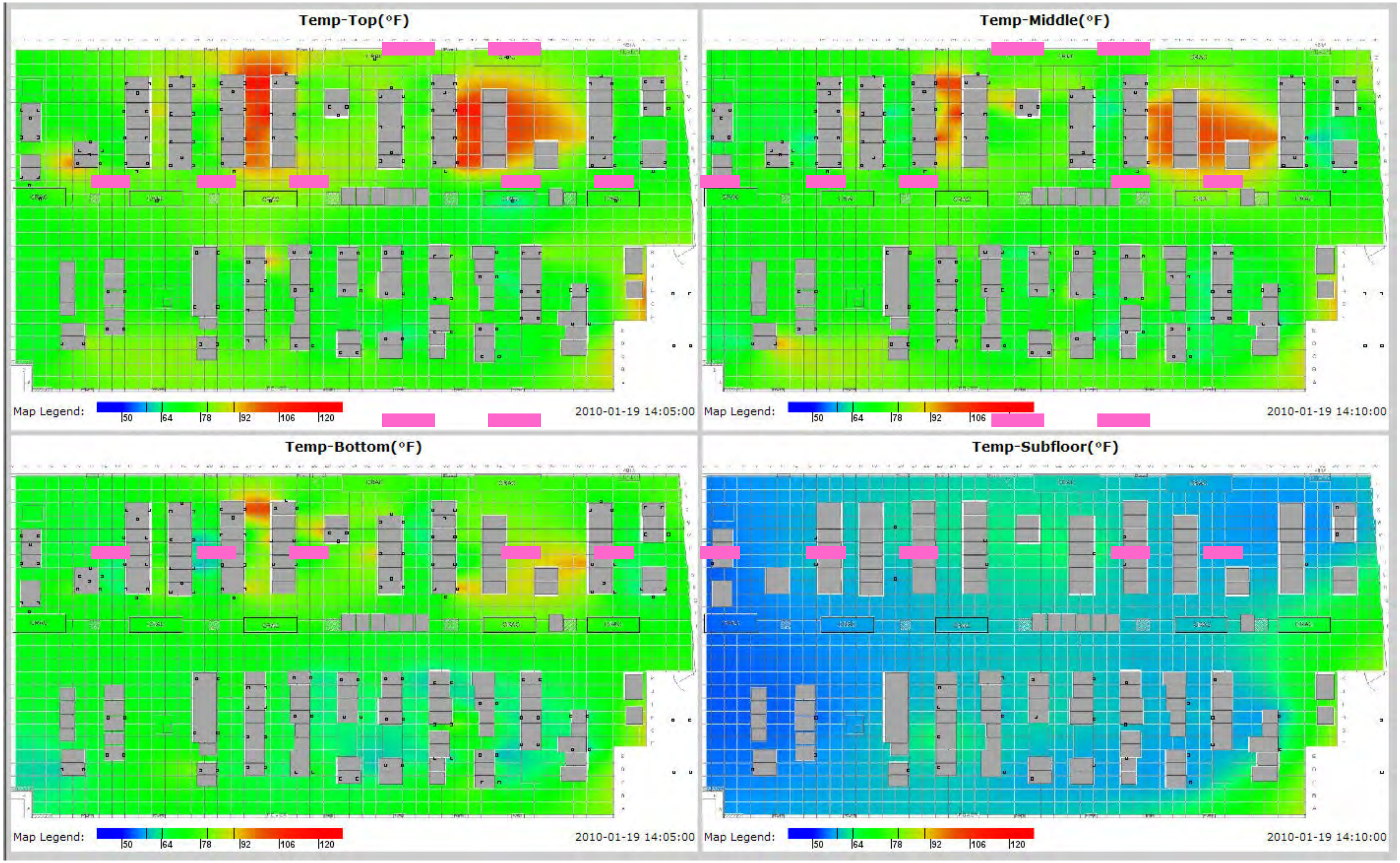

Feedback continues to help: Note impact of IT cart!

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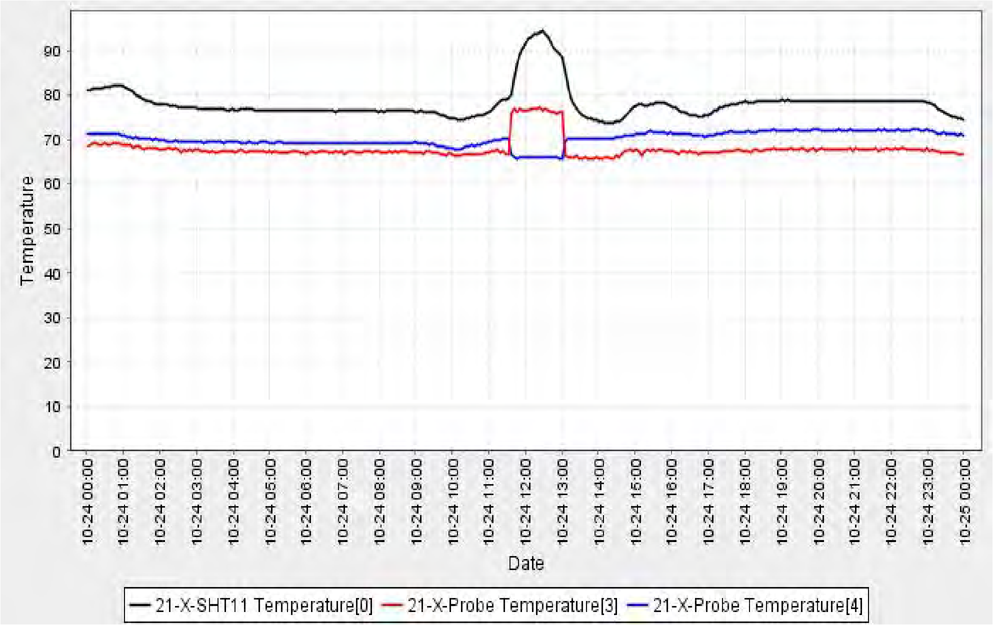
Real-time feedback identified cold aisle air flow obstruction!



Real-time PUE Display

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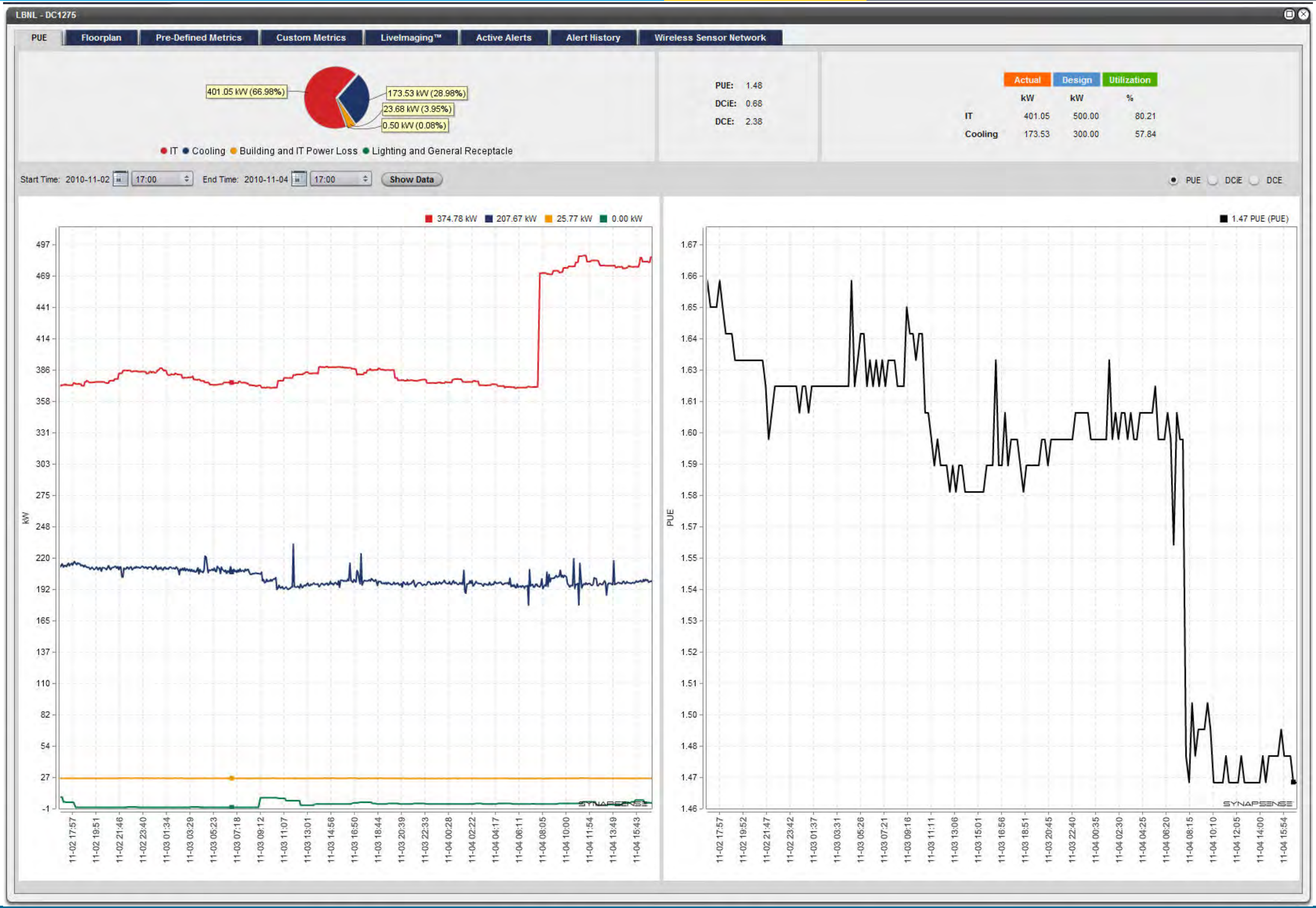

PUE Calculation Diagram

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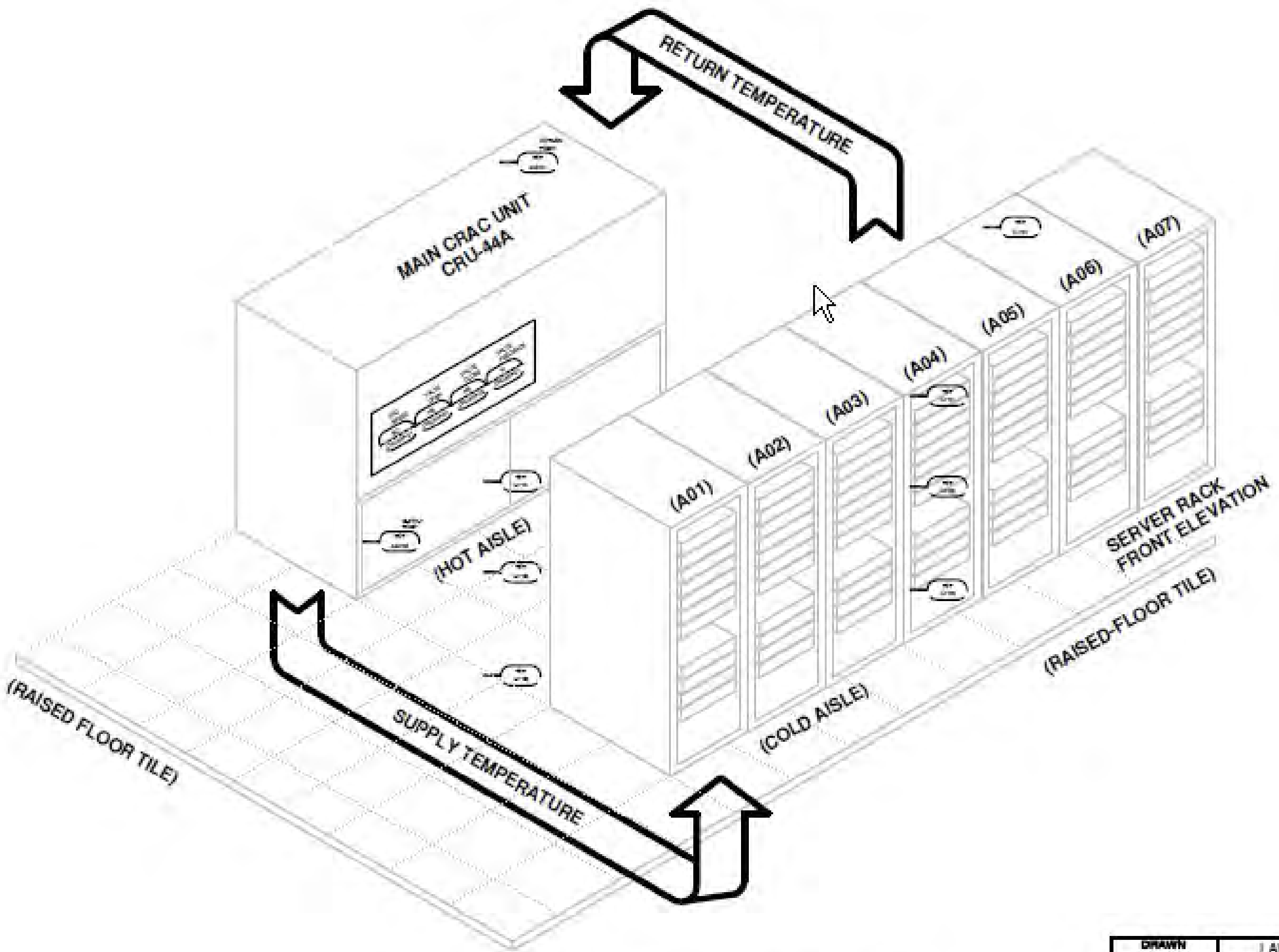
Control data center air conditioning using the *built-in* IT server-equipment temperature sensors

Intel Demonstration

- **Typically**, data center cooling devices use *return air temperature* as the primary control-variable
  - ASHRAE and IT manufacturers agree IT equipment inlet air temperature is the key operational parameter
  - Optimum control difficult
- Server inlet air temperature is available from ICT network
  - Intelligent Platform Management Interface (IPMI) or
  - Simple network management protocol (SNMP)
- Demonstration showed:
  - Servers can provide temperature data to facilities control system
  - Given server inlet temperature, facility controls improved temperature control and efficiency
  - Effective communications and control accomplished without significant interruption or reconfiguration of systems

Intel Data Center HVAC:



SC11 DATA CENTER HVAC MECHANICAL DIAGRAM

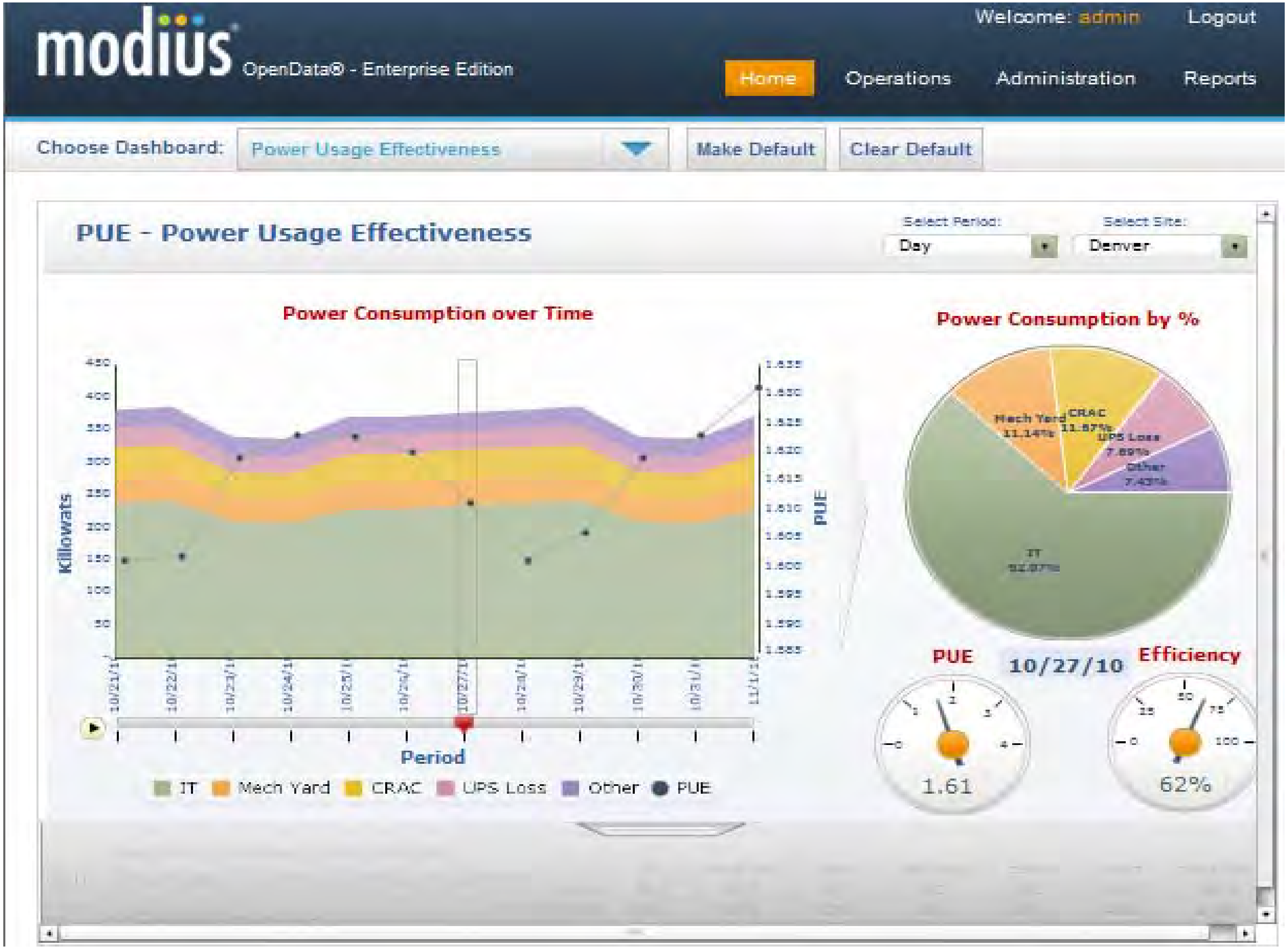
DRAWN	LAWRENCE BERKELEY NATIONAL LABORATORY INTEL CORPORATION
CHECKED	
DATE	HVAC CONTROLS DEMONSTRATION PROJECT
DWG. NO.	

Dashboards

Dashboards can display multiple systems' information for monitoring and maintaining data center performance

- Provide IT and HVAC system performance at a glance
- Identify operational problems
- Baseline energy use and benchmark performance
- View effects of changes
- Inform integrated decisions

Efficiency Dashboard Example…



Use IT to Manage IT: Summary

- **Evaluate monitoring systems to enhance operations and controls**
- **Install dashboards to manage and sustain energy efficiency.**

Environmental Conditions

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What are the main HVAC Energy Drivers?

- IT Load
- Climate
- **Room temperature and humidity**
  - **Most data centers are overcooled and have humidity control issues**
  - **Human comfort should not be a driver**

Environmental conditions

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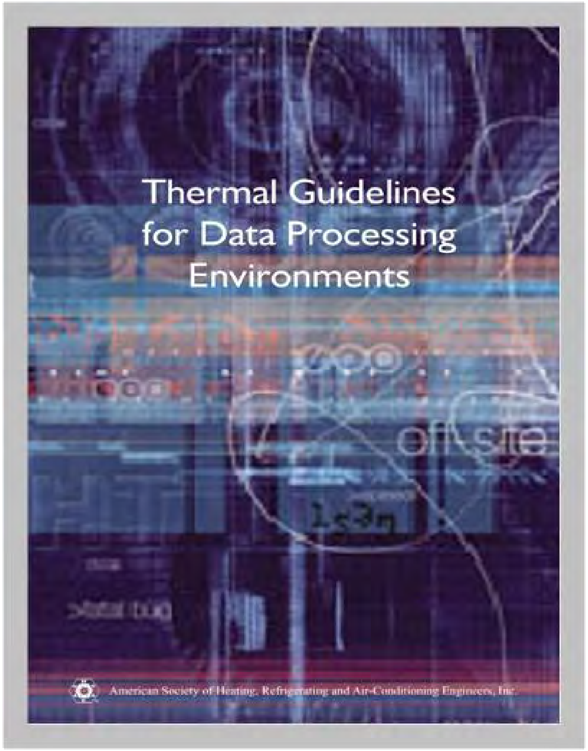
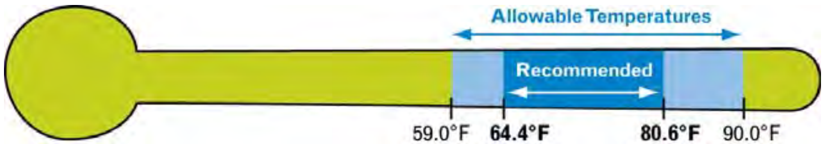
ASHRAE's Thermal Guidelines:

- Provide common understanding between IT and facility staff.
- Endorsed by IT manufacturers
- Enables large energy savings - especially when using economizers.
- Recommends temperature range of 18˚C to 27˚C (80.6°F) with "allowable" much higher
- New (2011) ASHRAE Guidelines
  - Six classes of equipment identified with wider allowable ranges from 32° C to 45° C (113°F).
  - Provides more justification for operating above the recommended limits (in the allowable range)
  - Provides wider humidity ranges





2011 ASHRAE Thermal Guidelines

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Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (˚C) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (˚C)	Maximum Elevation (m)	Maximum Rate of Change(˚C/hr) (f)	Dry-Bulb Temperature (˚C)	Relative Humidity (%)	Maximum Dew Point (˚C)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	18 to 27	5.5ºC DP to 60% RH and 15ºC DP						
Allowable								
A1	15 to 32	20% to 80% RH	17	3050	5/20	5 to 45	8 to 80	27
A2	10 to 35	20% to 80% RH	21	3050	5/20	5 to 45	8 to 80	27
A3	5 to 40	-12˚C DP & 8% RH to 85% RH	24	3050	5/20	5 to 45	8 to 85	27
A4	5 to 45	-12˚C DP & 8% RH to 90% RH	24	3050	5/20	5 to 45	8 to 90	27
B	5 to 35	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29
C	5 to 40	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29

2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance. White paper prepared by ASHRAE Technical Committee TC 9.9

2011 ASHRAE allowable ranges

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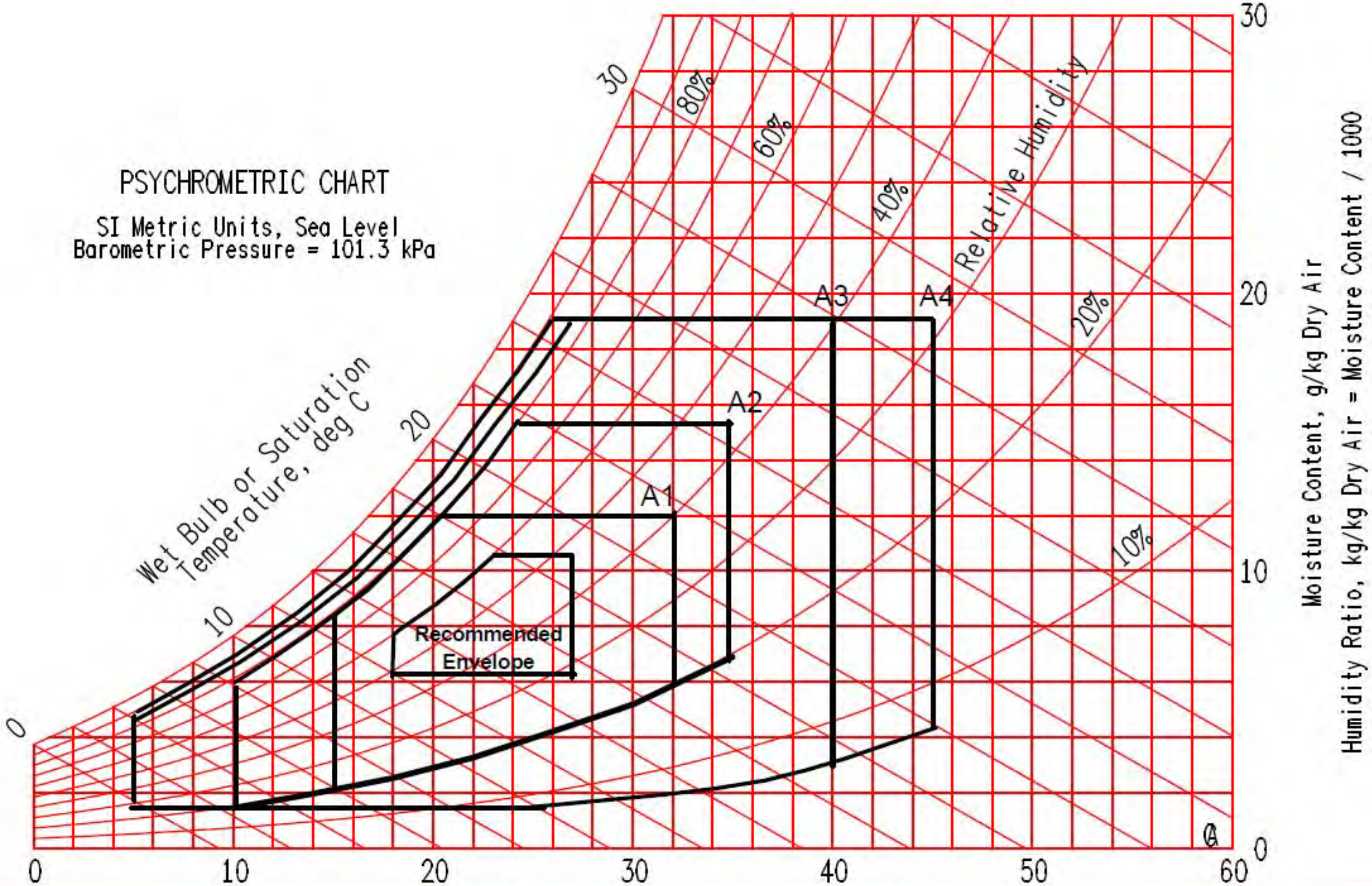

Dry Bulb Temperature

2011 ASHRAE Thermal Guidelines

ASHRAE's key conclusion when considering potential for increased failures at higher (allowable) temperatures:

"For a majority of US and European cities, the air-side and water-side economizer projections show failure rates that are very comparable to a traditional data center run at a steady state temperature of 20°C."

Environmental conditions: Summary

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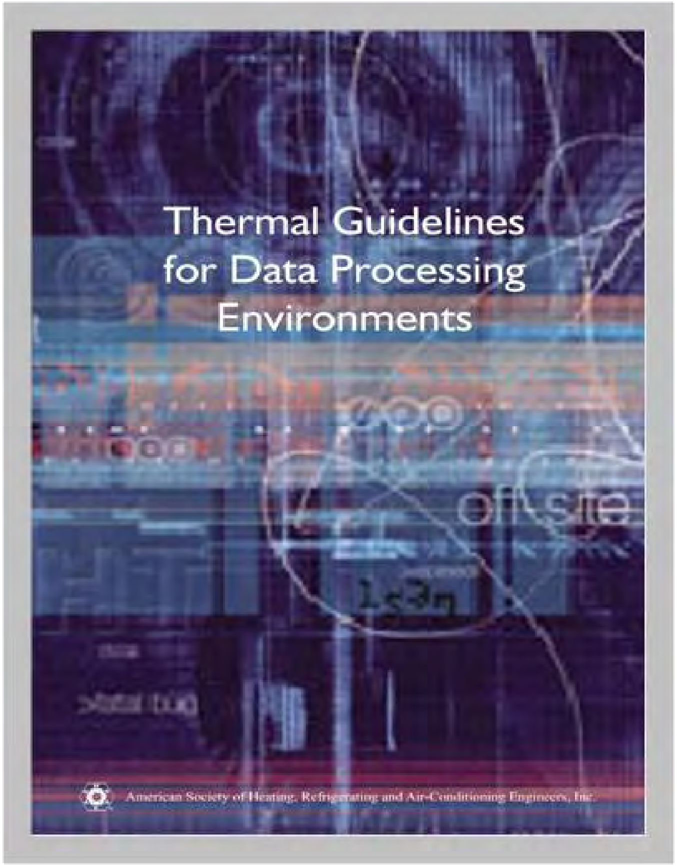
- A cold data center = efficiency opportunity
- Perceptions, based on old technology lead to cold data centers with tight humidity ranges – *this needs to change*
- Many IT manufacturers design for harsher conditions than ASHRAE guidelines
- Design Data Centers for IT equipment performance - *not people comfort*.
- Must address air management before raising temperature



Airflow Management

Effective Application and Use in Data Centers

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Air Management: The Early Days at LBNL

It was cold but hot spots were everywhere

Fans were used to redirect air

High flow tiles reduced air pressure

Air Management

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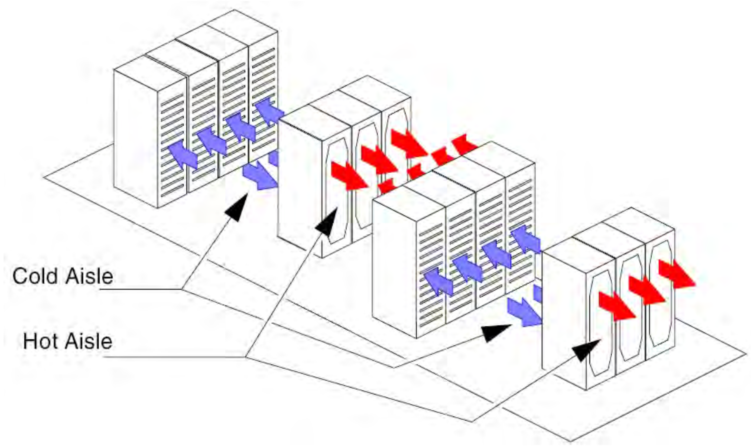
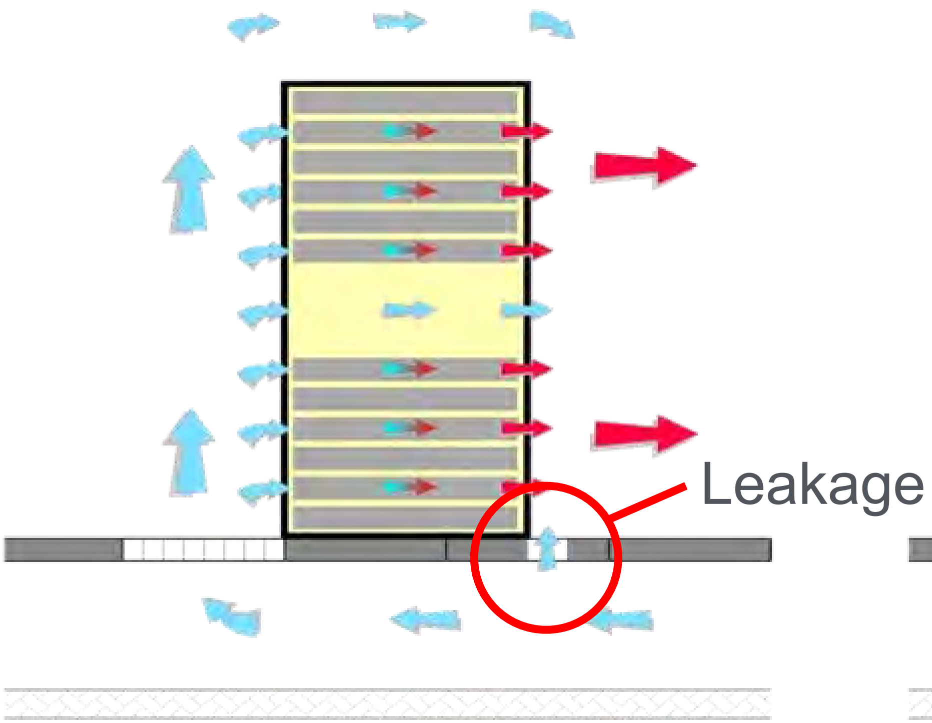
- Typically, more air circulated than required
- Air mixing and short circuiting leads to:
  - ➢ Low supply temperature
  - ➢ Low Delta T
- Use hot and cold aisles
- Improve isolation of hot and cold aisles
  - ➢ Reduce fan energy
  - ➢ Improve air-conditioning efficiency
  - ➢ Increase cooling capacity



Hot aisle / cold aisle configuration decreases mixing of intake & exhaust air, promoting efficiency.

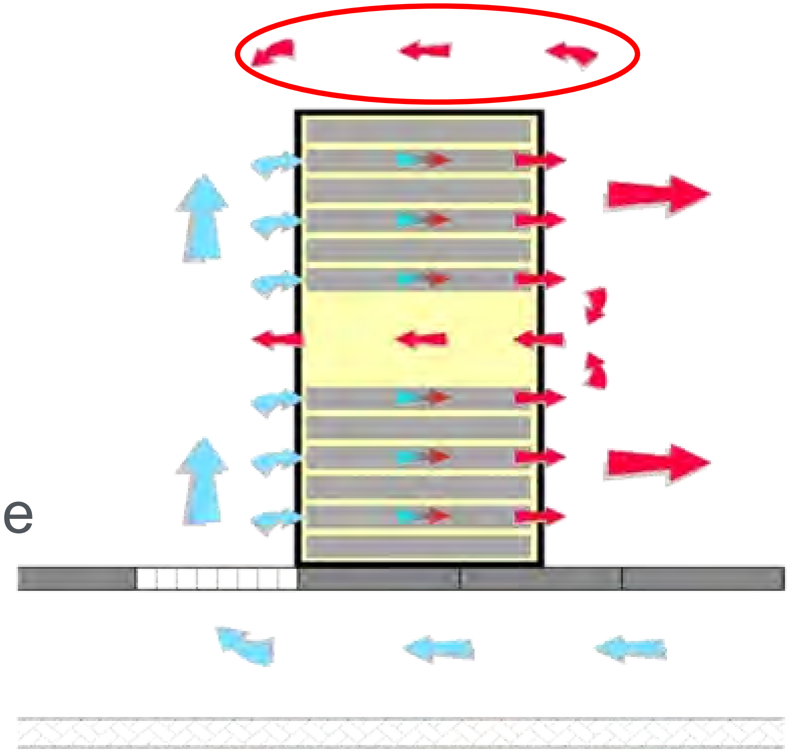
Reduce Bypass and Recirculation

Bypass Air / Short-Circuiting…



Wastes cooling capacity.

Recirculation…



Increases inlet temperature to servers.

Maintain Raised-Floor Seals

Maintain sealing of all potential leaks in the raised floor plenum.

Unsealed cable penetration

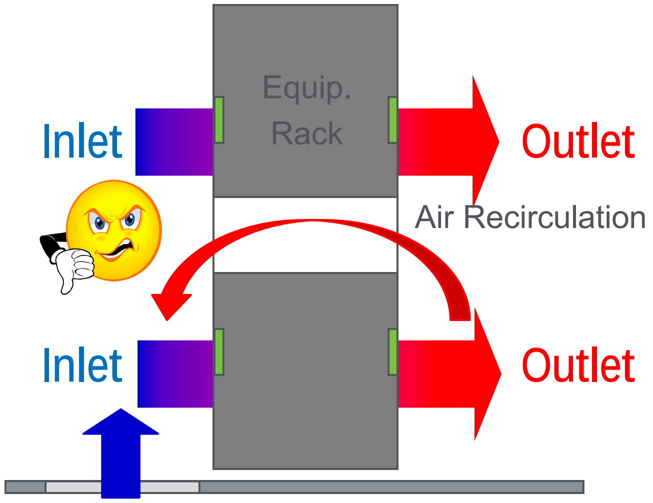
Sealed cable penetration

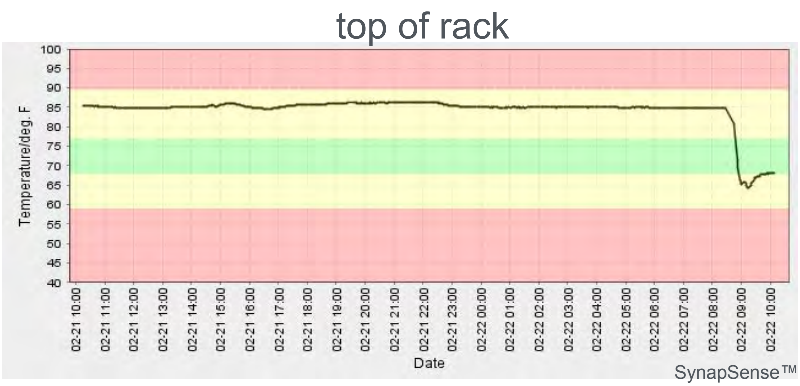
Manage Blanking Panels

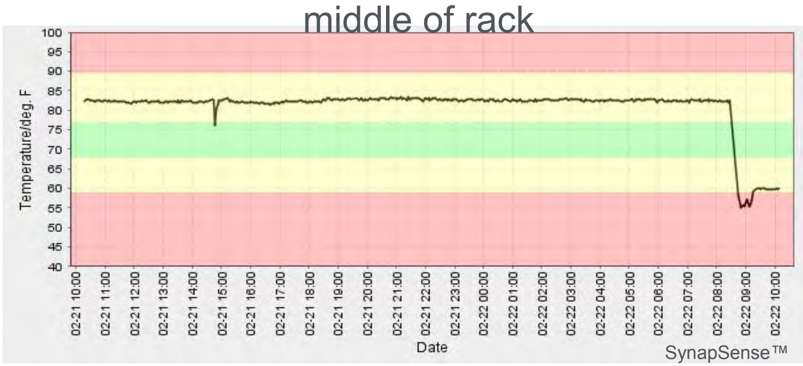
- Managing server blanking and side panels is very important.
- *Any* opening between the aisles will degrade the separation of hot and cold air.

➢ Maintain server blanking and side panels.

One 12” blanking panel added
Temperature dropped ~20°



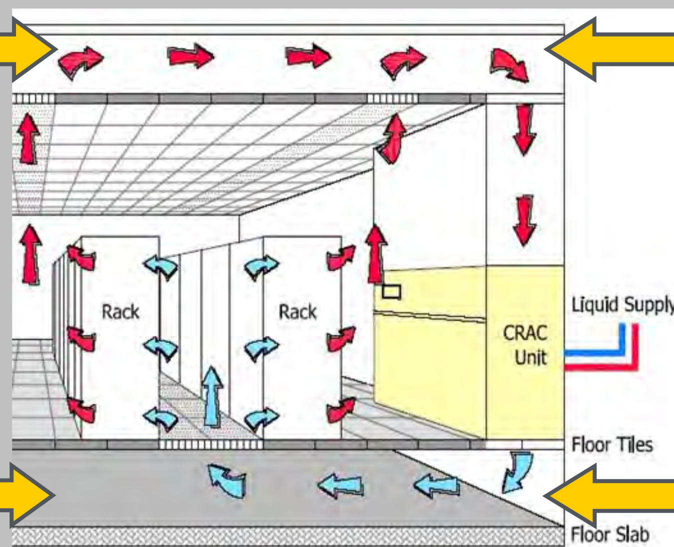




Reduce Airflow Restrictions & Congestion

Courtesy of dlb associates, consulting engineers

Courtesy of dlb associates, consulting engineers



Courtesy of dlb associates, consulting engineers

Courtesy of dlb associates, consulting engineers

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Consider The Impact That Congestion Has On The Airflow Patterns

Congested Floor & Ceiling Cavities

Empty Floor & Ceiling Cavities

Tune Floor Tiles

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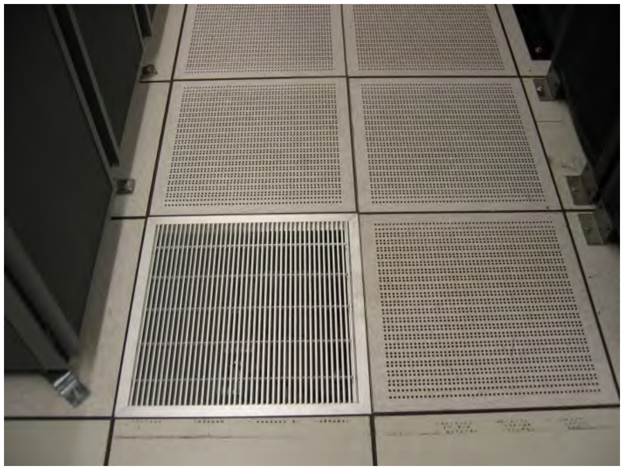
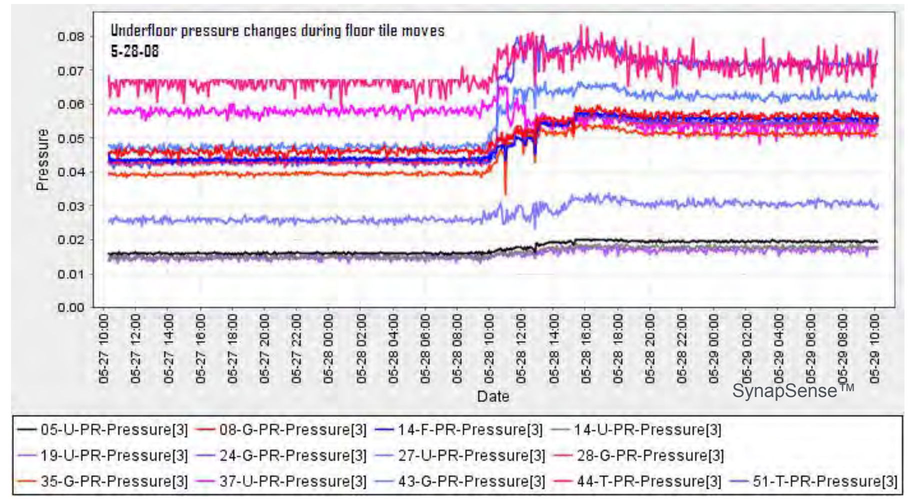
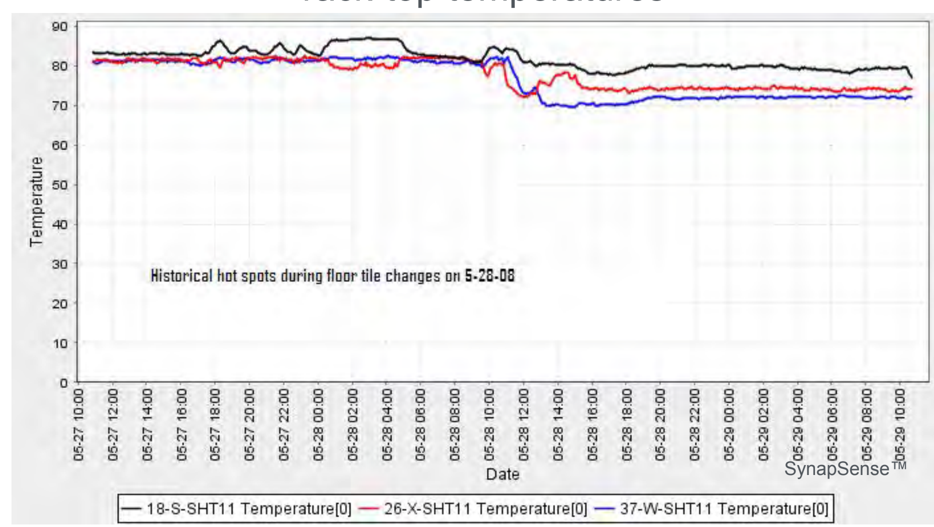


- Too many permeable floor tiles
- if airflow is optimized
  - under-floor pressure □
  - rack-top temperatures □
  - data center capacity increases
- Measurement and visualization assisted tuning process

under-floor pressures

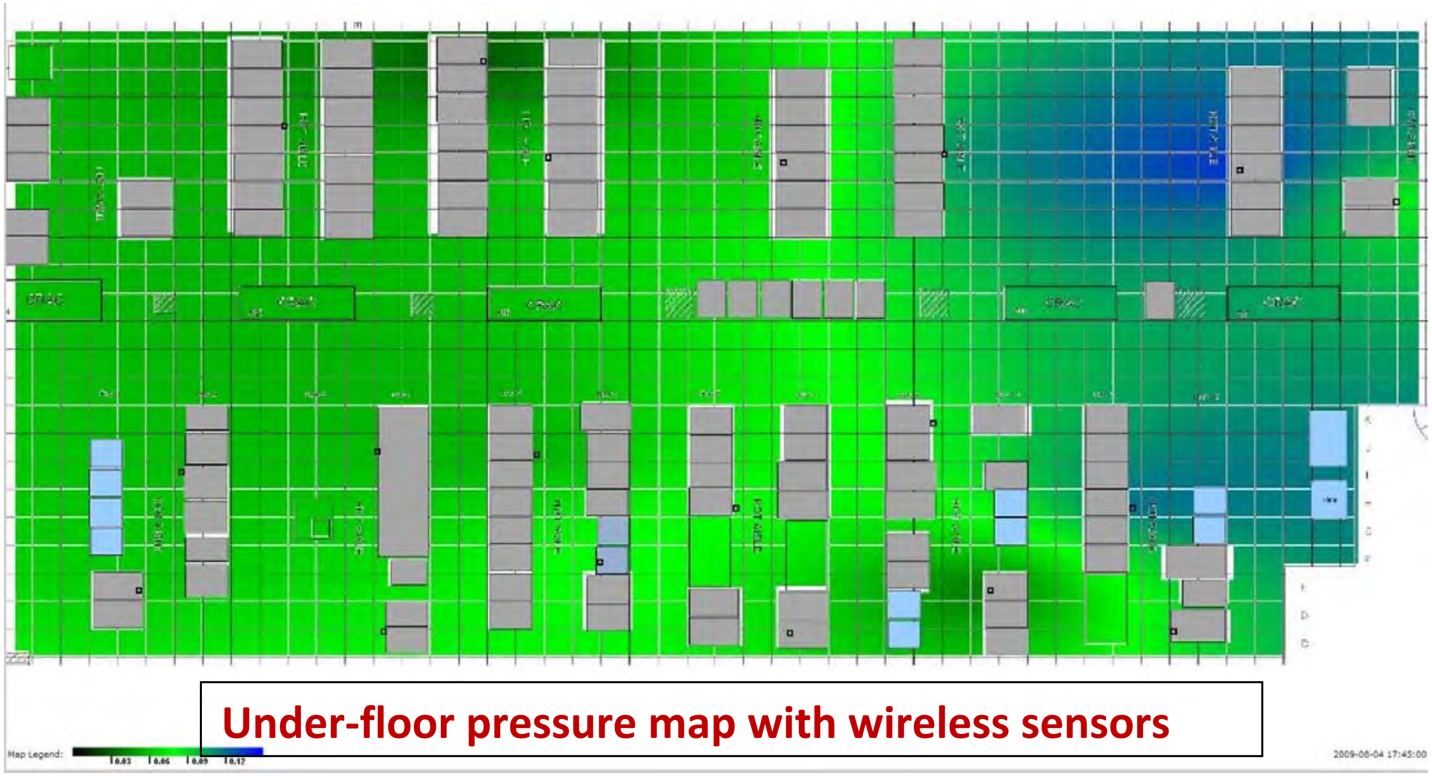


rack-top temperatures



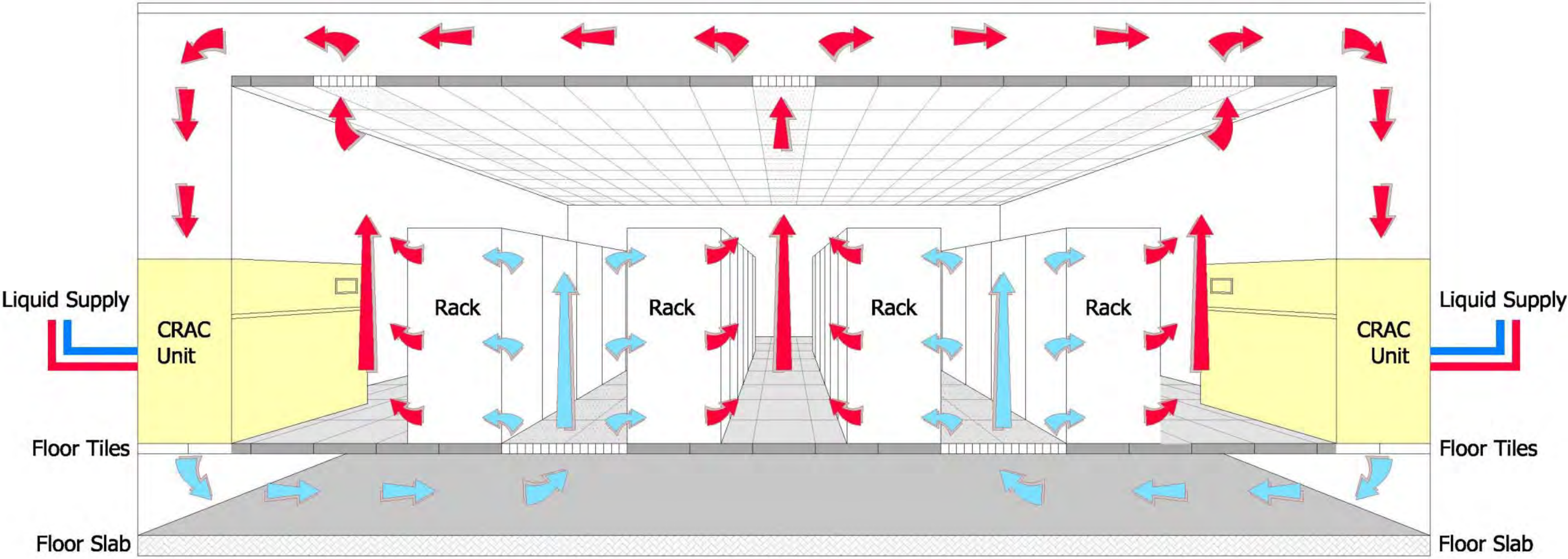
Resolve Airflow Balancing

- BALANCING is required to optimize airflow.
- Rebalancing needed with new IT or HVAC equipment
- Locate perforated floor tiles *only* in cold aisles



Under-floor pressure map with wireless sensors

Next step: Air Distribution Return-Air Plenum



Return air plenum

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- Overhead plenum converted to hot-air return
- Return registers placed over hot aisle
- CRAC intakes extended to overhead

Before

After

Adding Air Curtains for Hot/Cold Isolation

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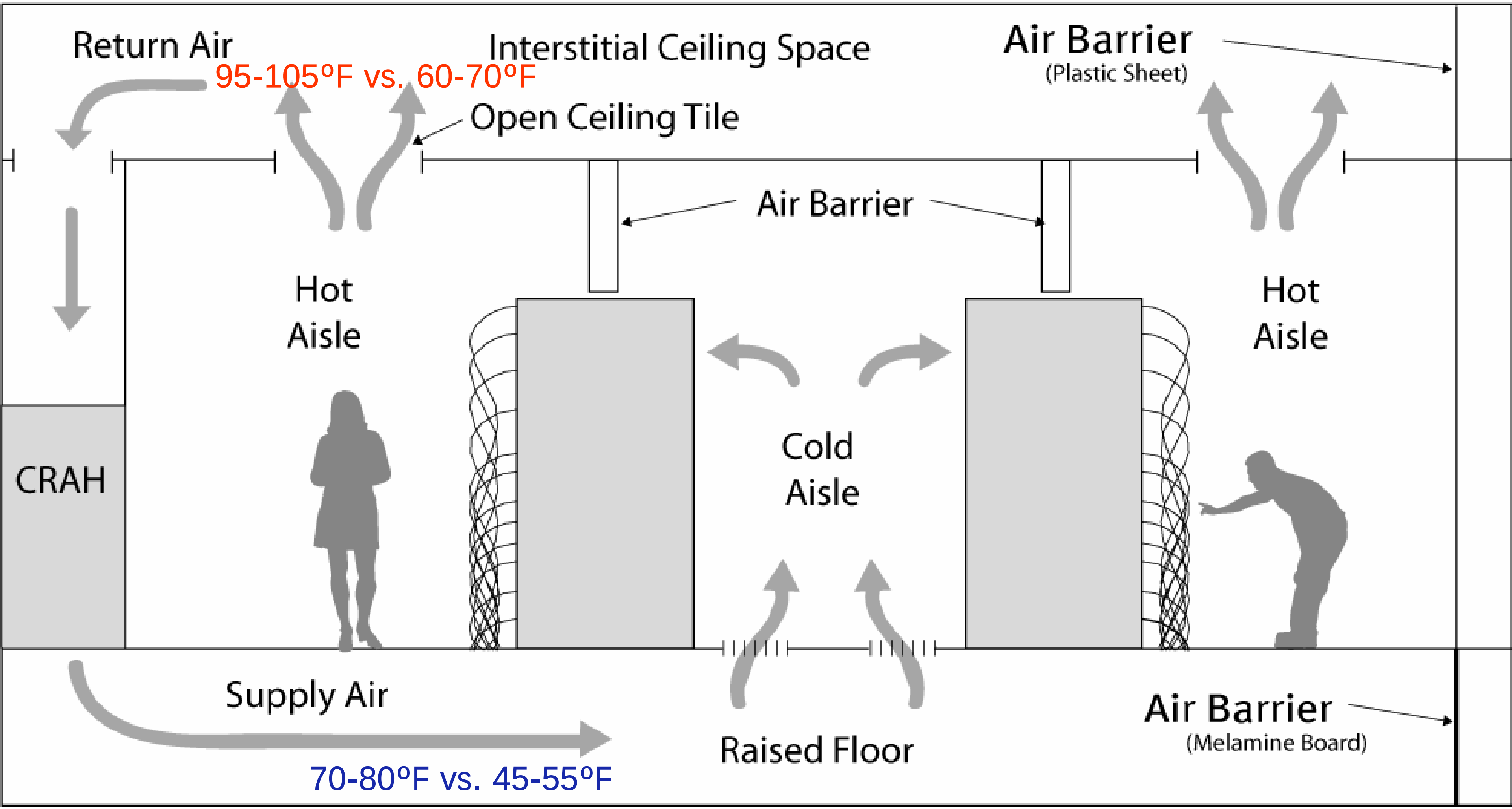
Improve Air Management: Isolate Cold and Hot Aisles



Efficient alternatives to under-floor air distribution

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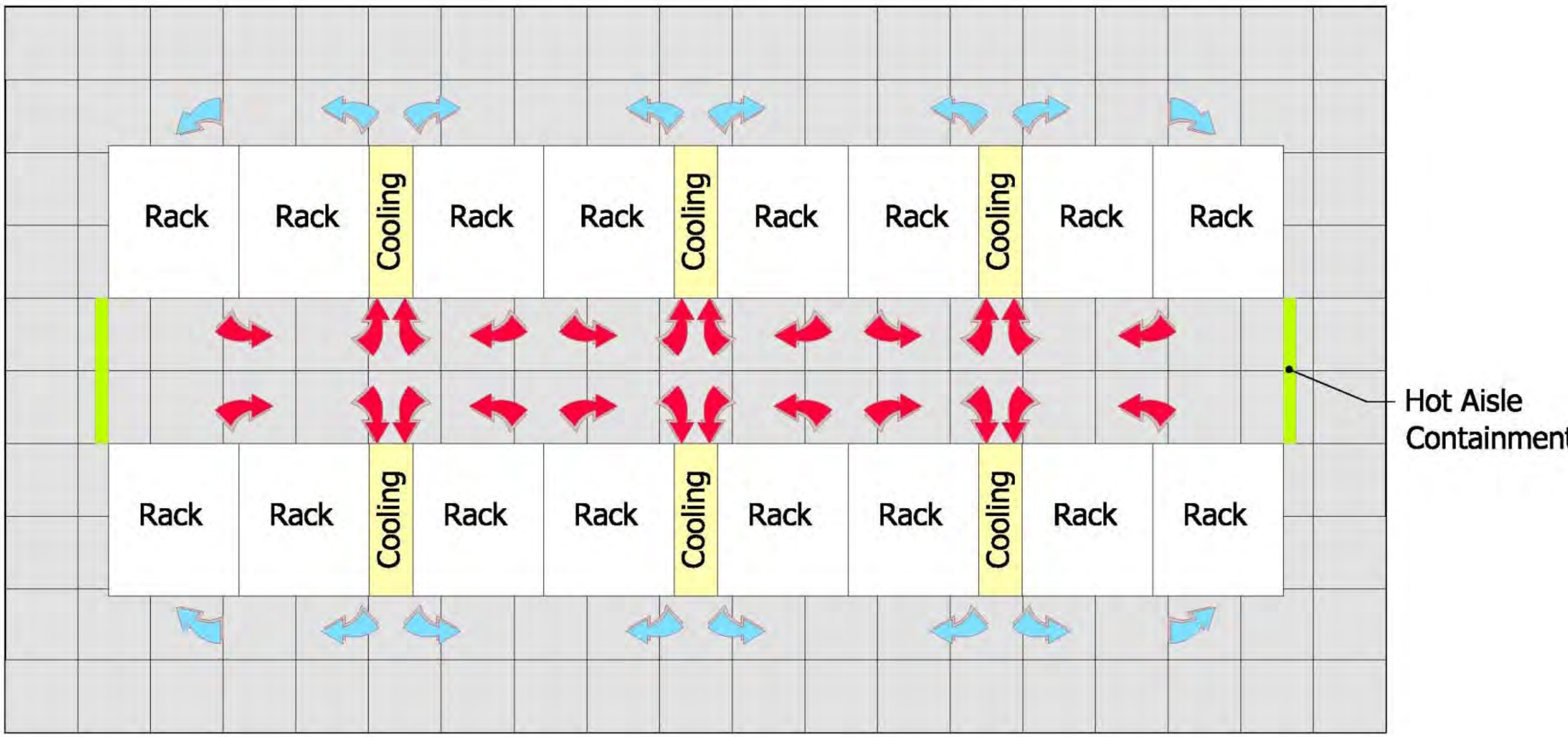
Localized air cooling systems with hot and cold isolation can be used to supplement or replace under-floor systems (raised floor not required!)

Examples include:

- **Row-based cooling units**
  - Cooling units placed in the rows of racks.
- **Rack-mounted heat exchangers**
  - Cool the hot exhaust air from the rack
- **Both options “Pre-engineer” hot and cold isolation**

Example – Local Row-Based Cooling



Review: Airflow Management Basics

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Air management techniques:

- Seal air leaks in floor (e.g. cable penetrations)
- Prevent recirculation with blanking panels in racks
- Manage floor tiles (e.g. no perforated tiles in hot aisle)
- Improve isolation of hot and cold air (e.g. return air plenum, curtains, or complete isolation)

Impact of good isolation:

- Supply airflow reduced
  - Fan savings up to 75%+
- Overall temperature can be raised
  - Cooling systems efficiency improves
  - Greater opportunity for economizer ("free" cooling)
- Cooling capacity increases

Cooling systems

Removing heat from data centers

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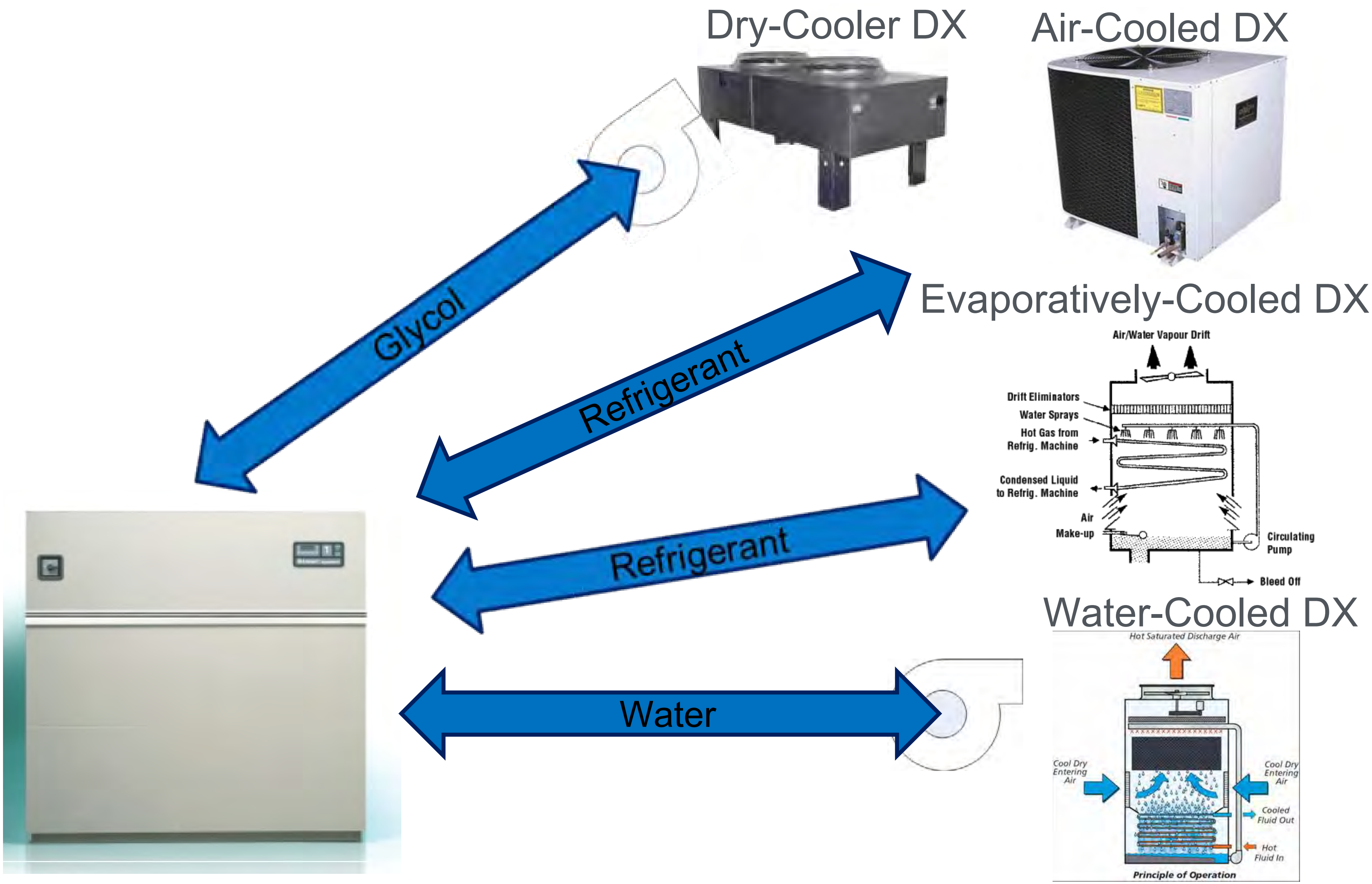
FEMP
Federal Energy Management Program

Berkeley Lab

Computer Room Air Conditioners (CRACs) and Air Handlers (CRAHs)

- **CRAC units**
  - Contain a fan, Direct Expansion (DX) cooling coil, and a refrigerant compressor.
- **CRAH units**
  - Contain a fan – air handler (AH) and chilled water cooling coil
  - Typically in larger facilities with a chiller plant
- **Both often equipped with humidifiers and reheat for dehumidification**
- **Often independently controlled**
  - Tight ranges and poor sensor calibration lead to units fighting

DX (or AC) units reject heat outside…



Computer Room Air Handling (CRAH) units use Chilled-Water

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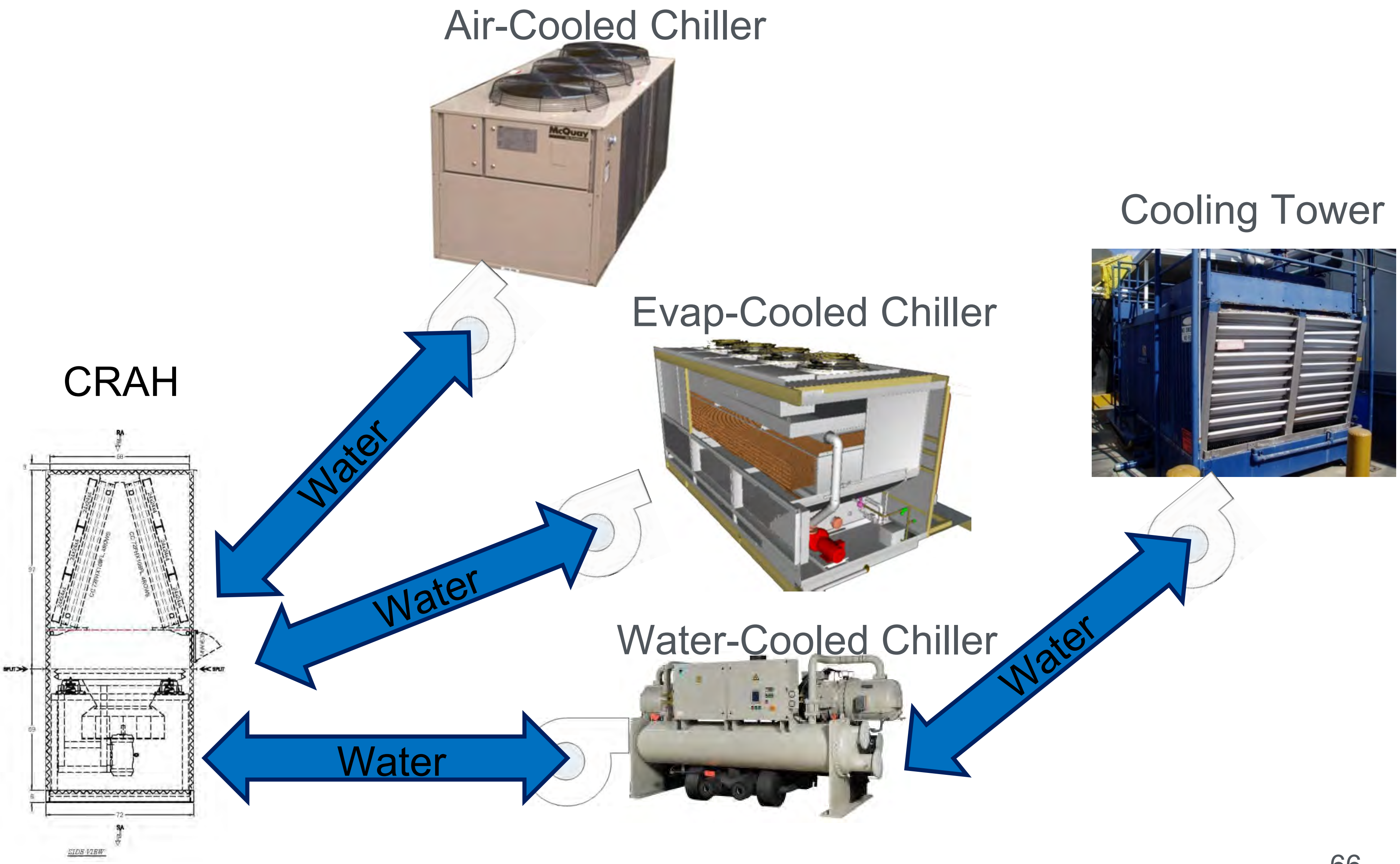

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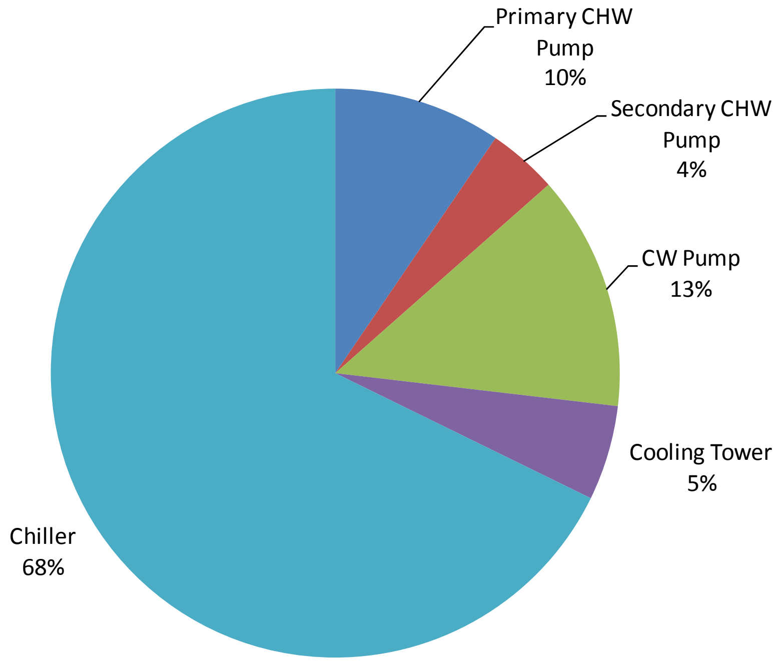
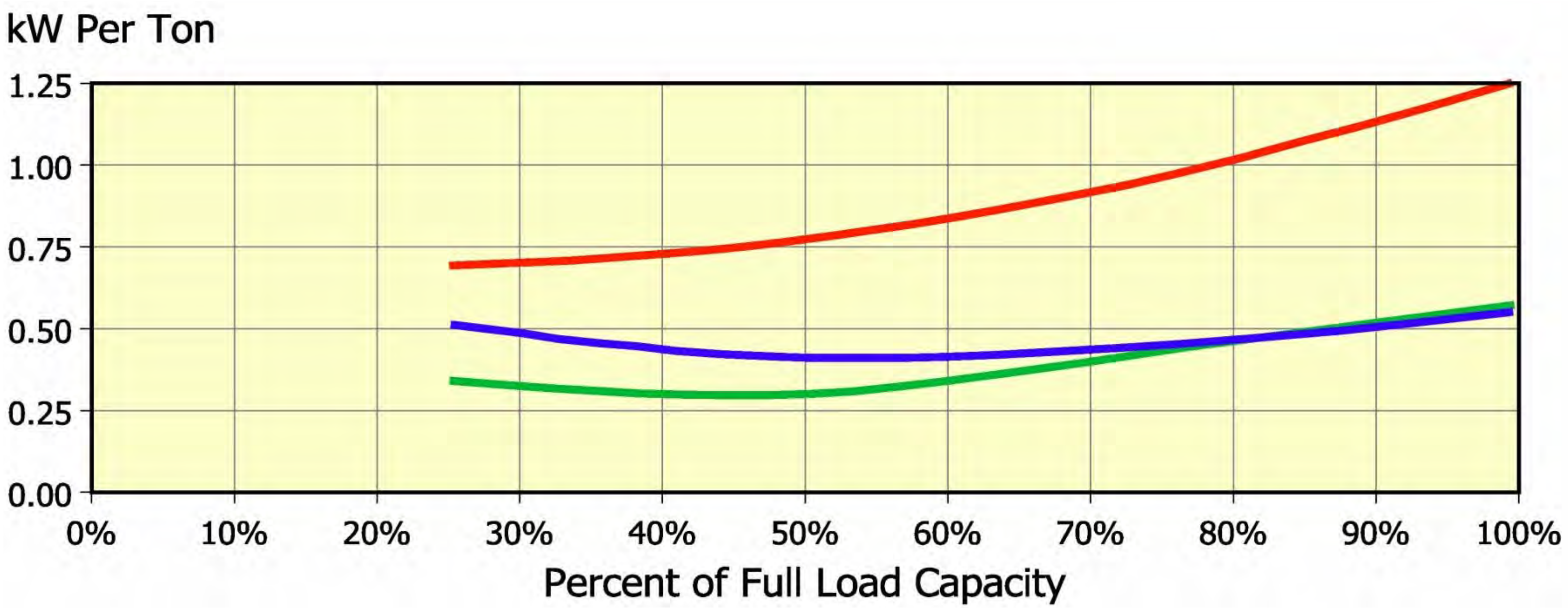
Optimize the Chiller Plant

- Have a plant (vs. distributed cooling)
- Use “warm” water cooling (multi-loop)
- Size cooling towers for “free” cooling
- Integrate controls and monitor efficiency of all primary components
- Thermal storage
- Utilize variable speed drives on:
  - Fans
  - Pumps
  - Towers
  - Chillers

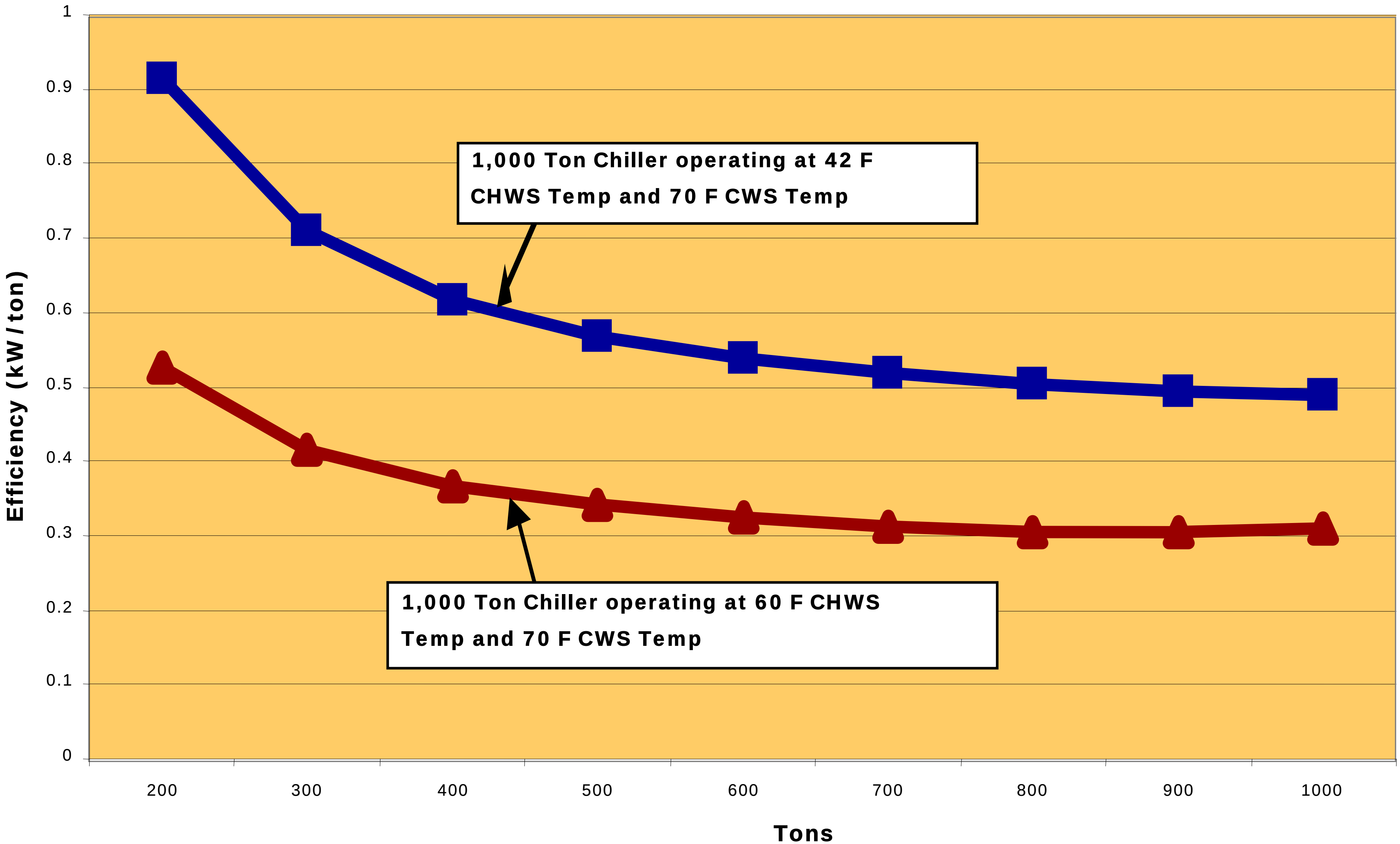


Select Efficient Chillers

Chiller	Compressor kW / ton			
	25%	50%	75%	100%
400 Ton Air Cooled	0.69	0.77	0.96	1.25
1200 Ton Water Cooled w/o VFD	0.51	0.41	0.45	0.55
1200 Ton Water Cooled with a VFD	0.34	0.30	0.43	0.57



Increase Temperature of Chiller Plant



Data provided by York International Corporation.

As heat densities rise, liquid solutions become more attractive (again):

Volumetric heat capacity comparison

Water

=

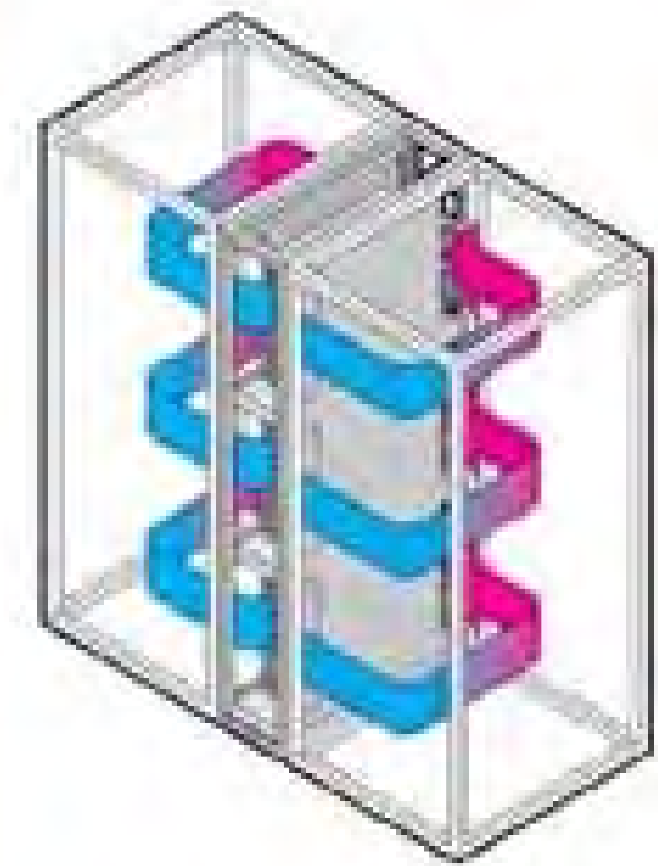
Air

Why Liquid Cooling?

- Heat removal efficiency increases as liquid gets closer to the heat source
- Liquids can provide cooling with higher temperature coolant
  - Improved cooling efficiency
  - Increased economizer hours
  - Greater potential use of waste heat
- Reduced transport energy:

Heat Transfer		Resultant Energy Requirements			
Rate	ΔT	Heat Transfer Medium	Fluid Flow Rate	Conduit Size	Theoretical Horsepower
10 Tons	12°F	Forced Air	9217 cfm	34" Ø	3.63 Hp
		Water	20 gpm	2" Ø	.25 Hp

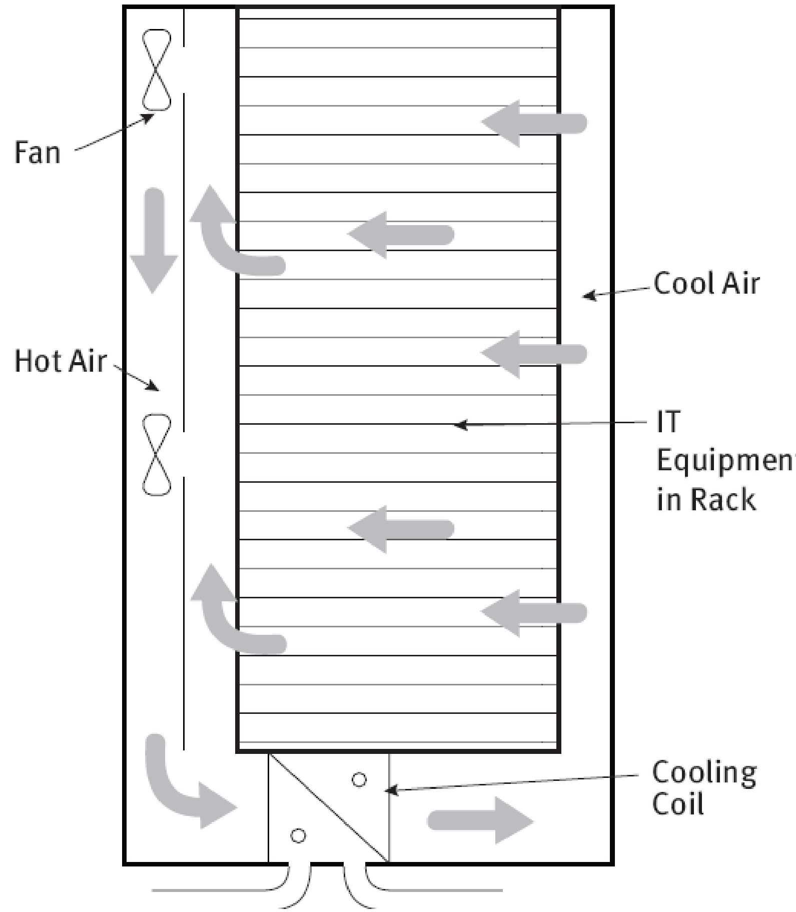
In-Row Cooling



Graphics courtesy of Rittal

In rack liquid cooling

Racks with integral coils and full containment



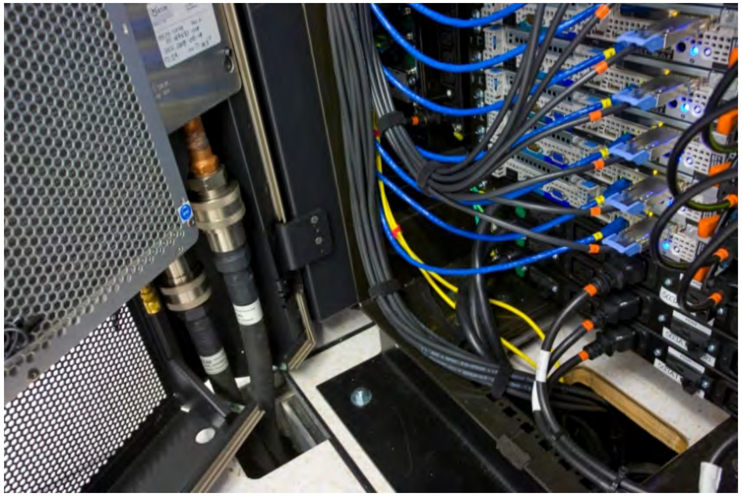
Rear-Door Liquid Cooling

Rear Door (open)

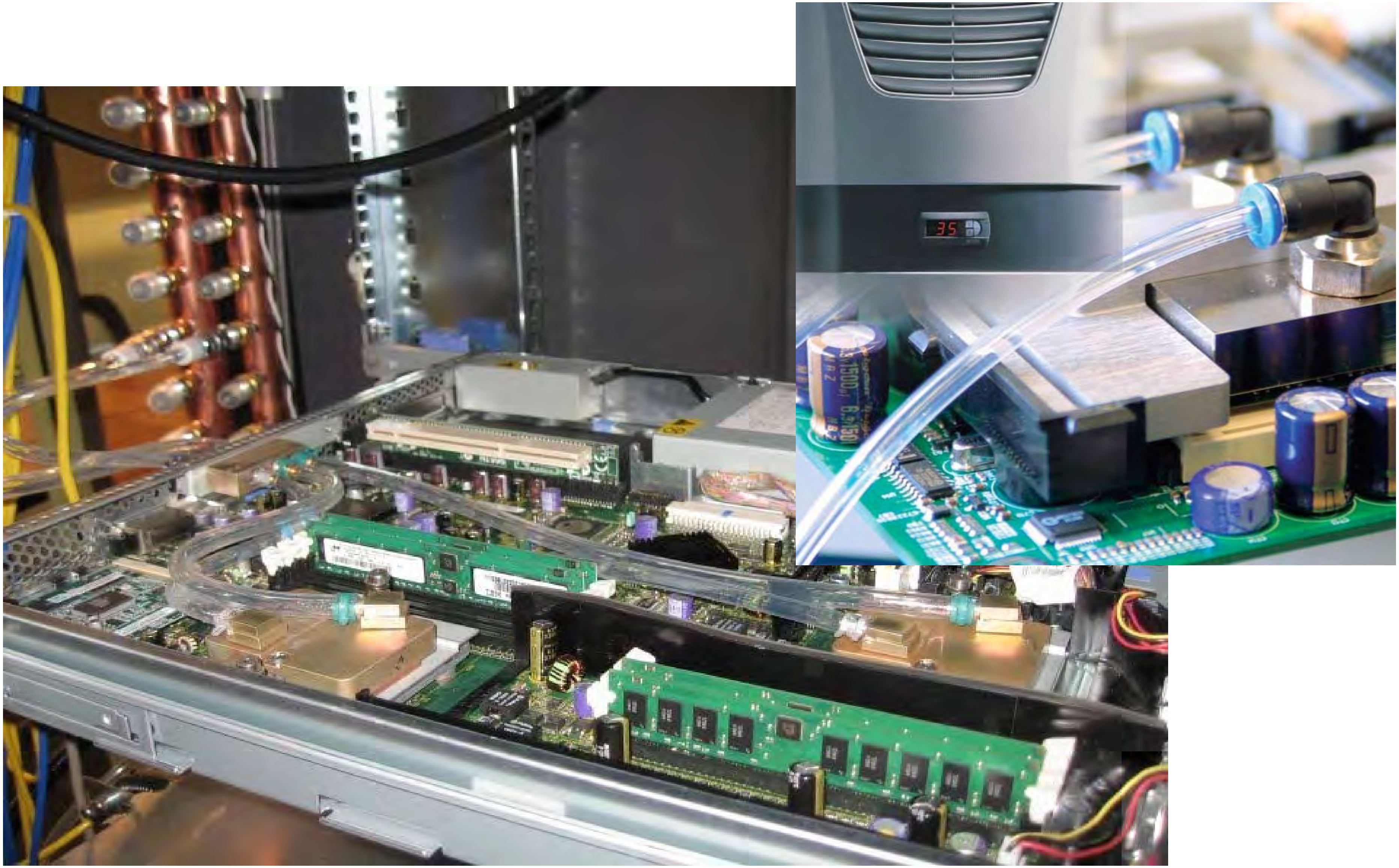
Inside rack RDHx, open 90°

Rear Doors (closed)

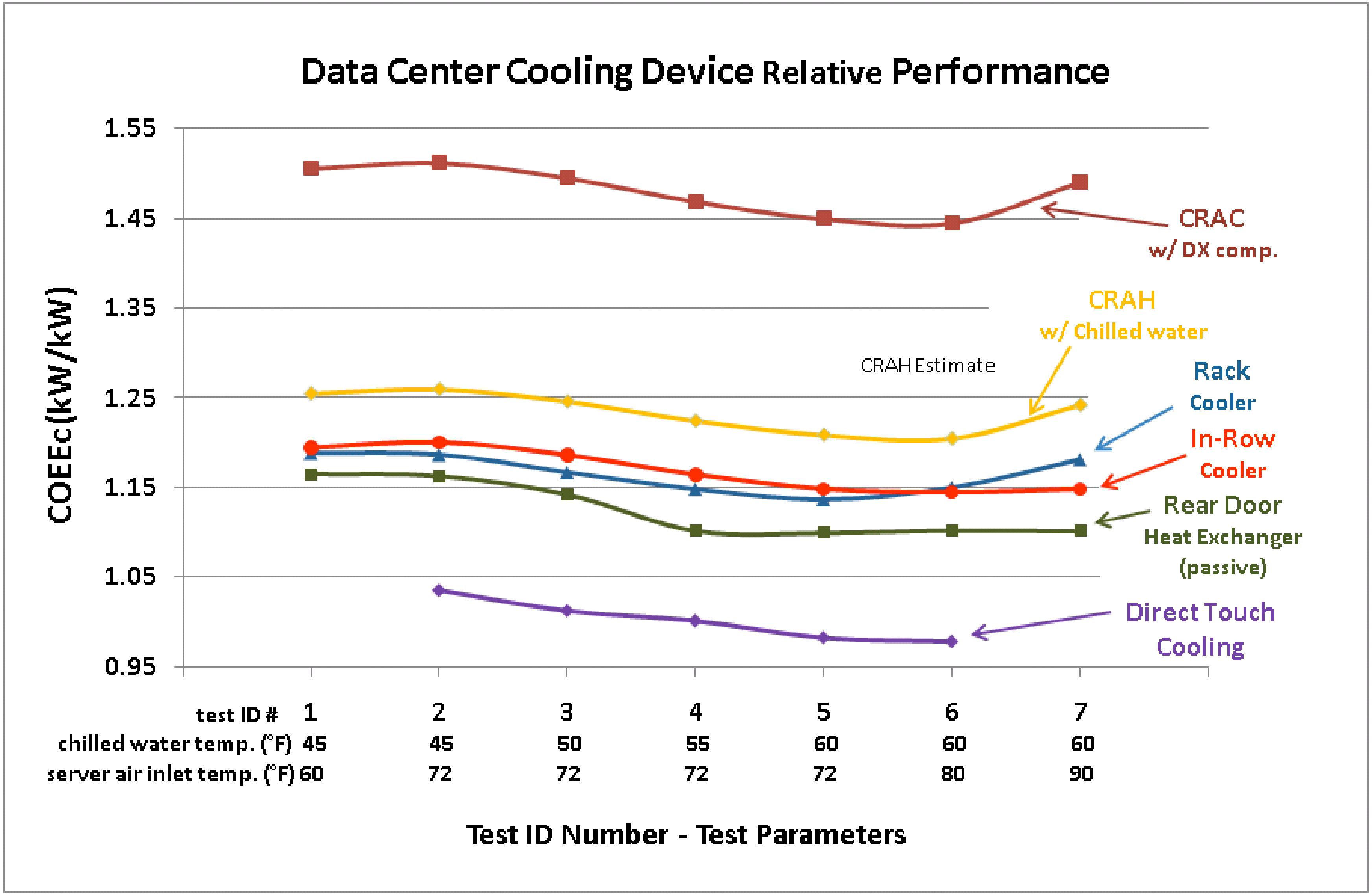
Liquid Cooling Connections



On Board Cooling



“Chill-off 2” evaluation of liquid cooling solutions



Use Free Cooling:

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Cooling without Compressors:

- Outside-Air Economizers
- Water-side Economizers
- ➢ Let's get rid of chillers in data centers

Avg. Power for Cooling	
HVAC Cooling	23%
HVAC Fans	8%
TOTAL	31%

Using 100% Economizer

Energy Savings = 23 / 31

= 74%

Outside-Air Economizers

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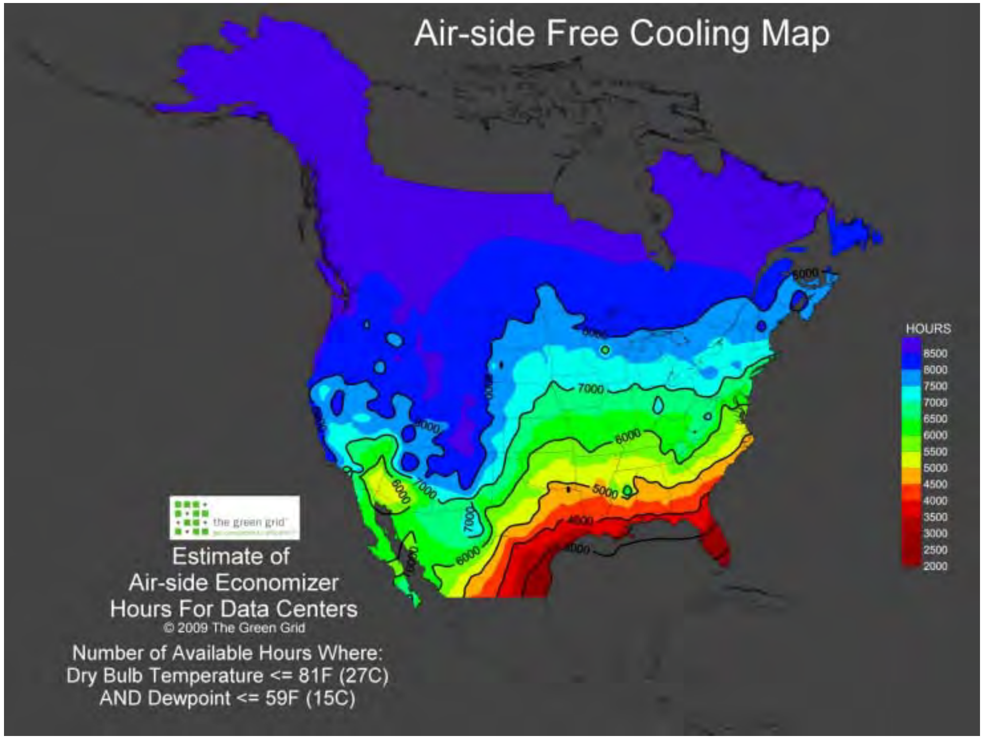
Advantages

- Lower energy use
- Added reliability (backup for cooling system)

Potential Issues

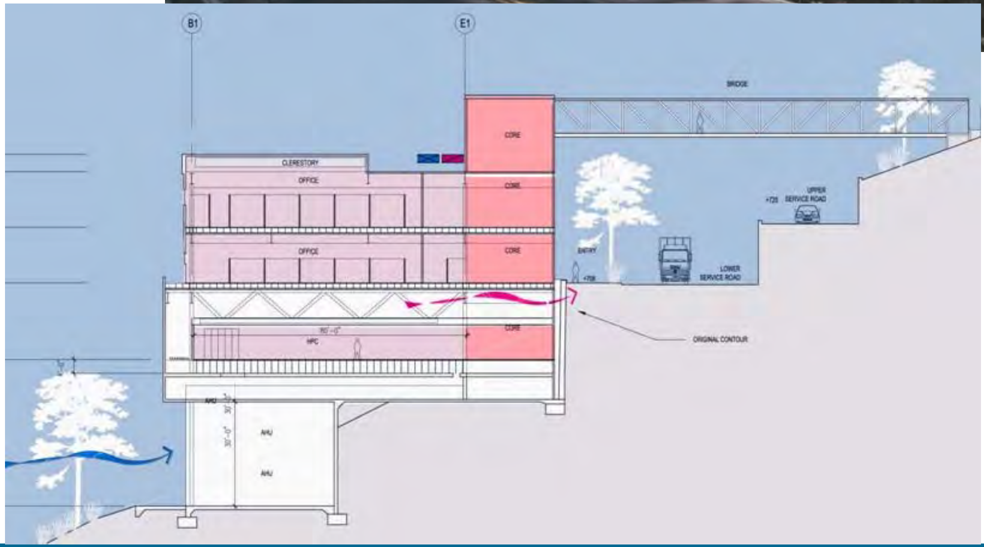
- Installation space.
- Dust
  - Not a concern with Merv 13 filters
- Gaseous contaminants
  - Not widespread
  - Impacts normally cooled data centers as well
- Shutdown or bypass if smoke is outside data center.



http://cooling.thegreengrid.org/namerica/WEB_APP/calc_index.html

System Design Approach:

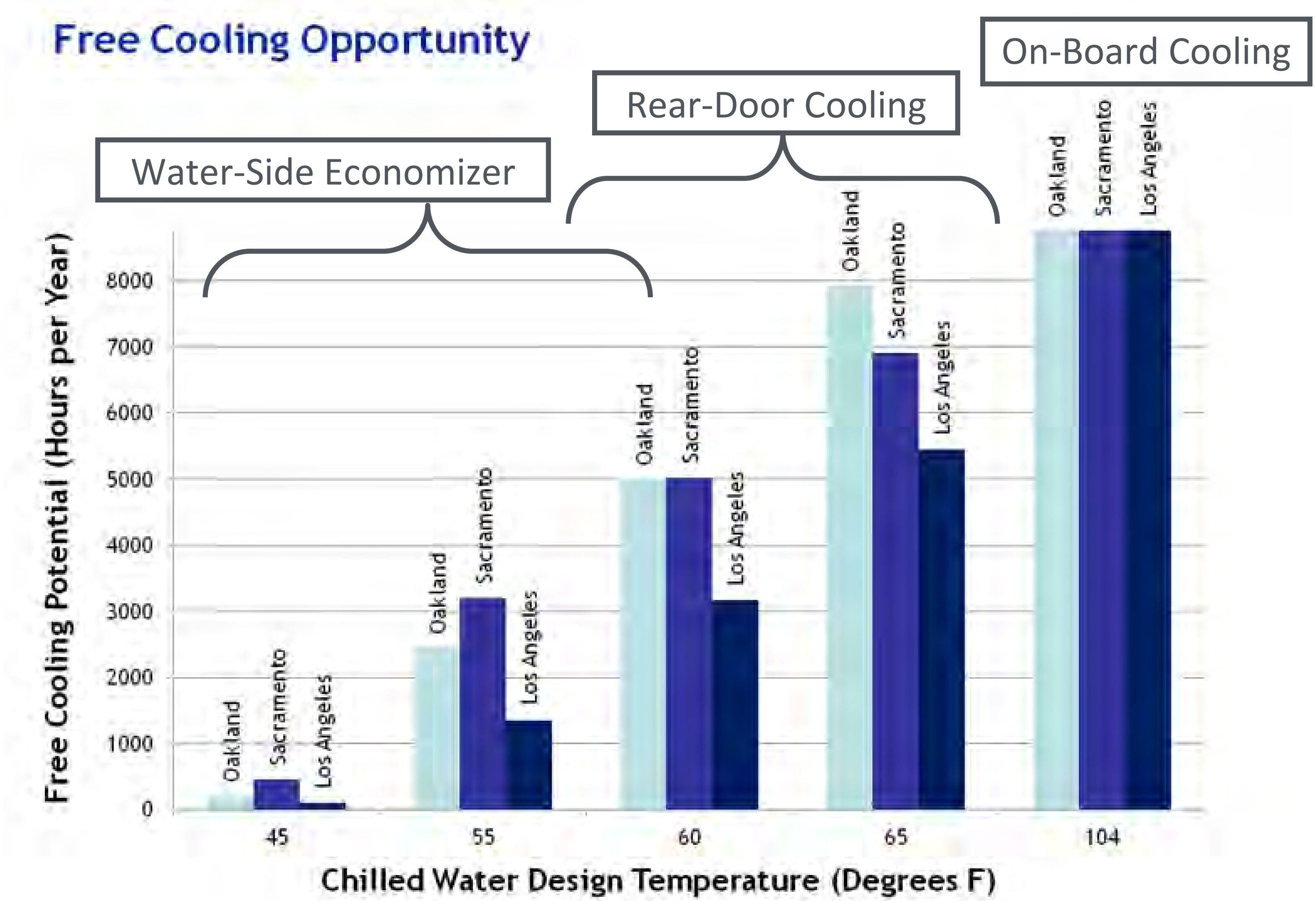
- Free cooling
- Air-side economizer (93% of hours)
  - Direct evaporative cooling for humidification and pre-cooling
- Liquid cooling also available
  - Tower side economizer
  - Four pipe system
- Waste heat reuse
- Annual PUE = 1.1 (predicted)



Advantages

- Cost effective in cool and dry climates
- Often easier retrofit
- Added reliability (backup in the event of chiller failure).
- No contamination questions

Potential for Tower Cooling



LBNL Example: Rear Door Cooling

- **Used instead of adding CRAC units**
- **Rear door water cooling with tower-only (or central chiller plant in series).**
  - **Both options significantly more efficient than existing direct expansion (DX) CRAC units.**

Improve Humidity Control:

- Eliminate inadvertent dehumidification
  - Computer load is sensible only
- Use ASHRAE allowable humidity ranges
  - Many manufacturers allow even wider ranges
- Defeat equipment fighting
  - Coordinate controls
- Disconnect and only control humidity of makeup air or one CRAC/CRAH unit
- Entirely disconnect (many have!)

Cost of Unnecessary Humidification

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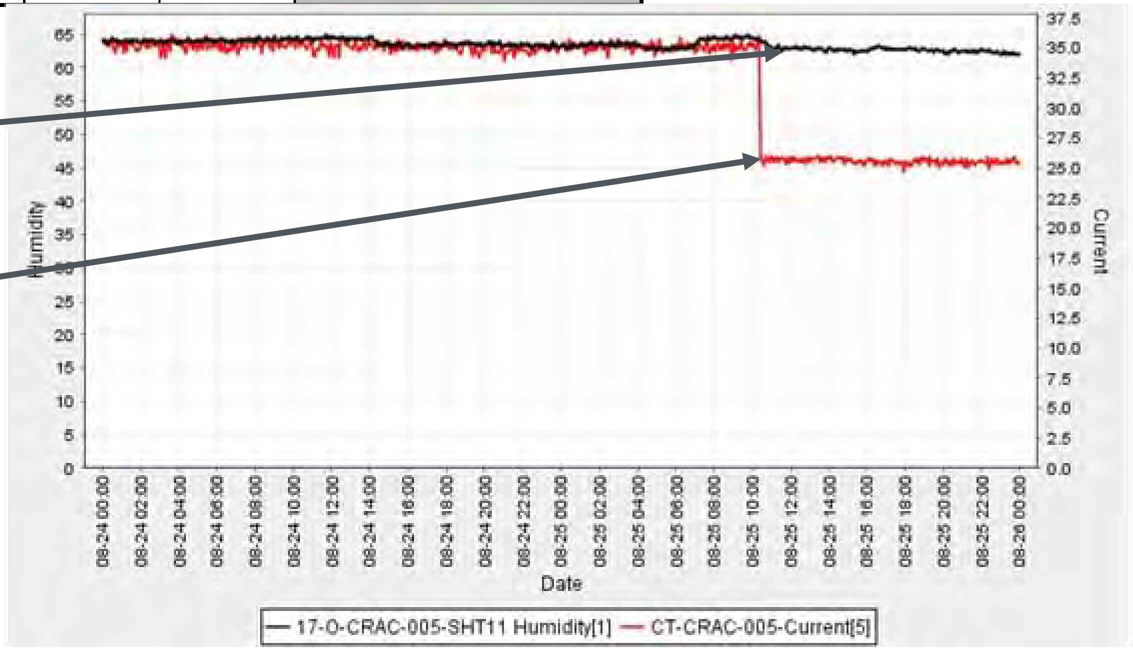
	Visalia Probe			CRAC Unit Panel			
	Temp	RH	Tdp	Temp	RH	Tdp	Mode
AC 005	84.0	27.5	47.0	76	32.0	44.1	Cooling
AC 006	81.8	28.5	46.1	55	51.0	37.2	Cooling & Dehumidification
AC 007	72.8	38.5	46.1	70	47.0	48.9	Cooling
AC 008	80.0	31.5	47.2	74	43.0	50.2	Cooling & Humidification
AC 010	77.5	32.8	46.1	68	45.0	45.9	Cooling
AC 011	78.9	31.4	46.1	70	43.0	46.6	Cooling & Humidification
Min	72.8	27.5	46.1	55.0	32.0	37.2	
Max	84.0	38.5	47.2	76.0	51.0	50.2	
Avg	79.2	31.7	46.4	68.8	43.5	45.5	

Humidity down ~2%

CRAC power down 28%



Cooling Takeaways…

- Use a central plant (e.g. chiller/CRAHs) vs. CRAC units
- Use centralized controls on CRAC/CRAH units
  - Prevent simultaneous humidifying and dehumidifying
  - Optimize sequence and staging
- Move to liquid cooling (room, row, rack, chip)
- Consider VSDs on fans, pumps, chillers, and towers
- Use air- or water-side economizers where possible.
- Expand humidity range and improve humidity control (or disconnect).

Electrical Systems

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Electrical system end use – Orange bars

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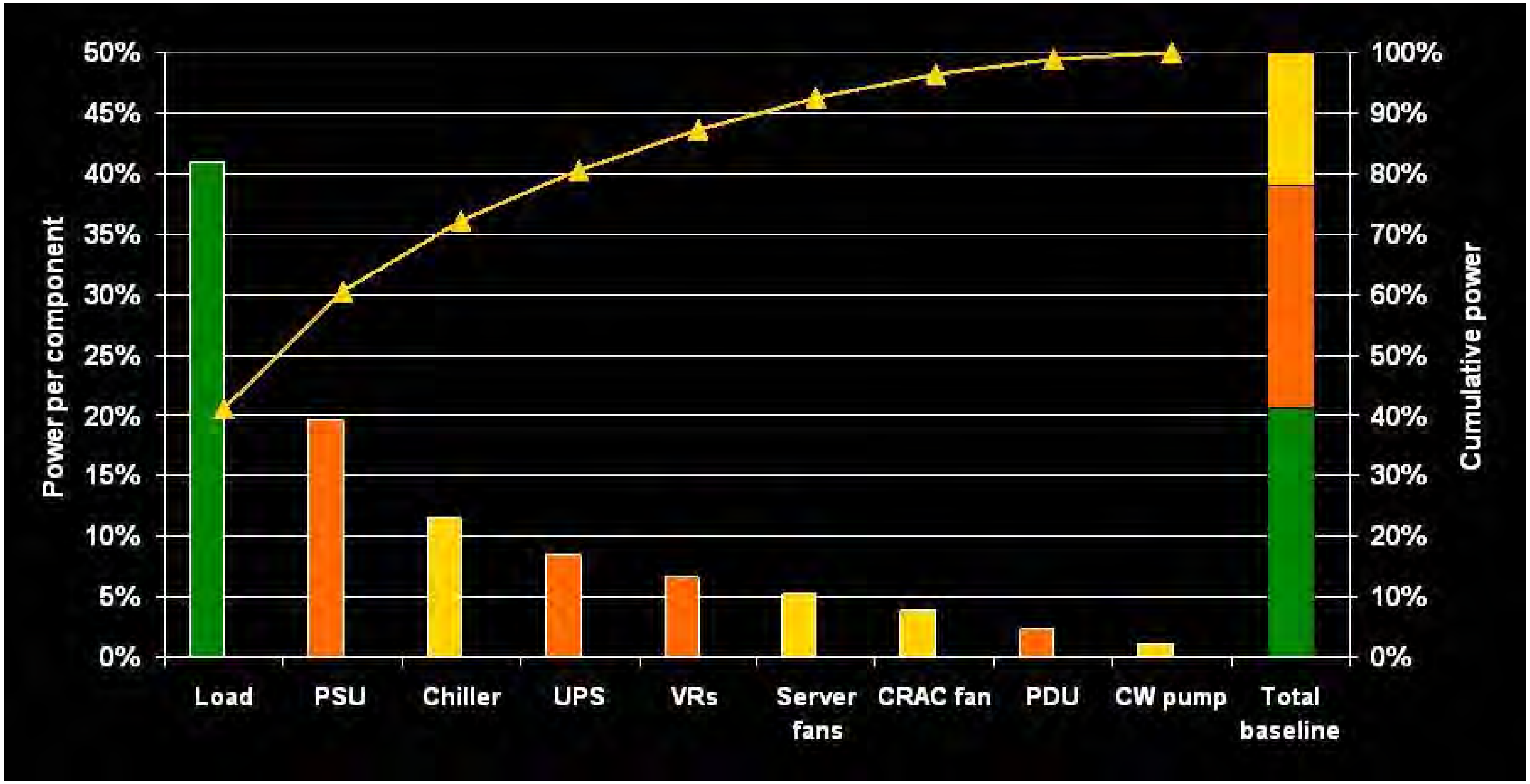

Courtesy of Michael Patterson, Intel Corporation

Electrical Distribution

- Every power conversion (AC-DC, DC-AC, AC-AC) loses some energy and creates heat
- Efficiency decreases when systems are lightly loaded
  - Redundancy should be used only to the required level (N+1 is much different than 2N)
- Distributing higher voltage is more efficient and saves capital cost (conductor size is smaller)
- Power supplies, Uninterruptible power supply (UPS), transformer, and PDU efficiencies vary – carefully select
- Lowering distribution losses also lowers cooling loads

UPS, transformer, & PDU efficiency

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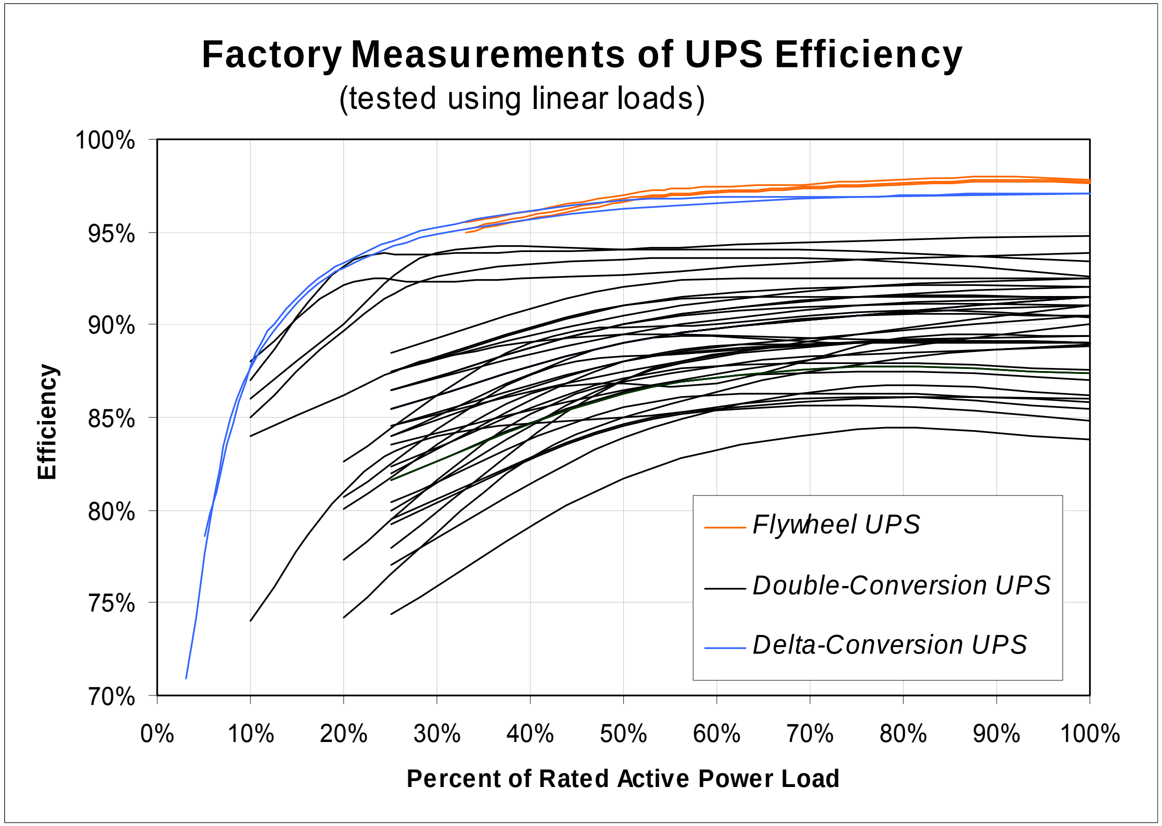
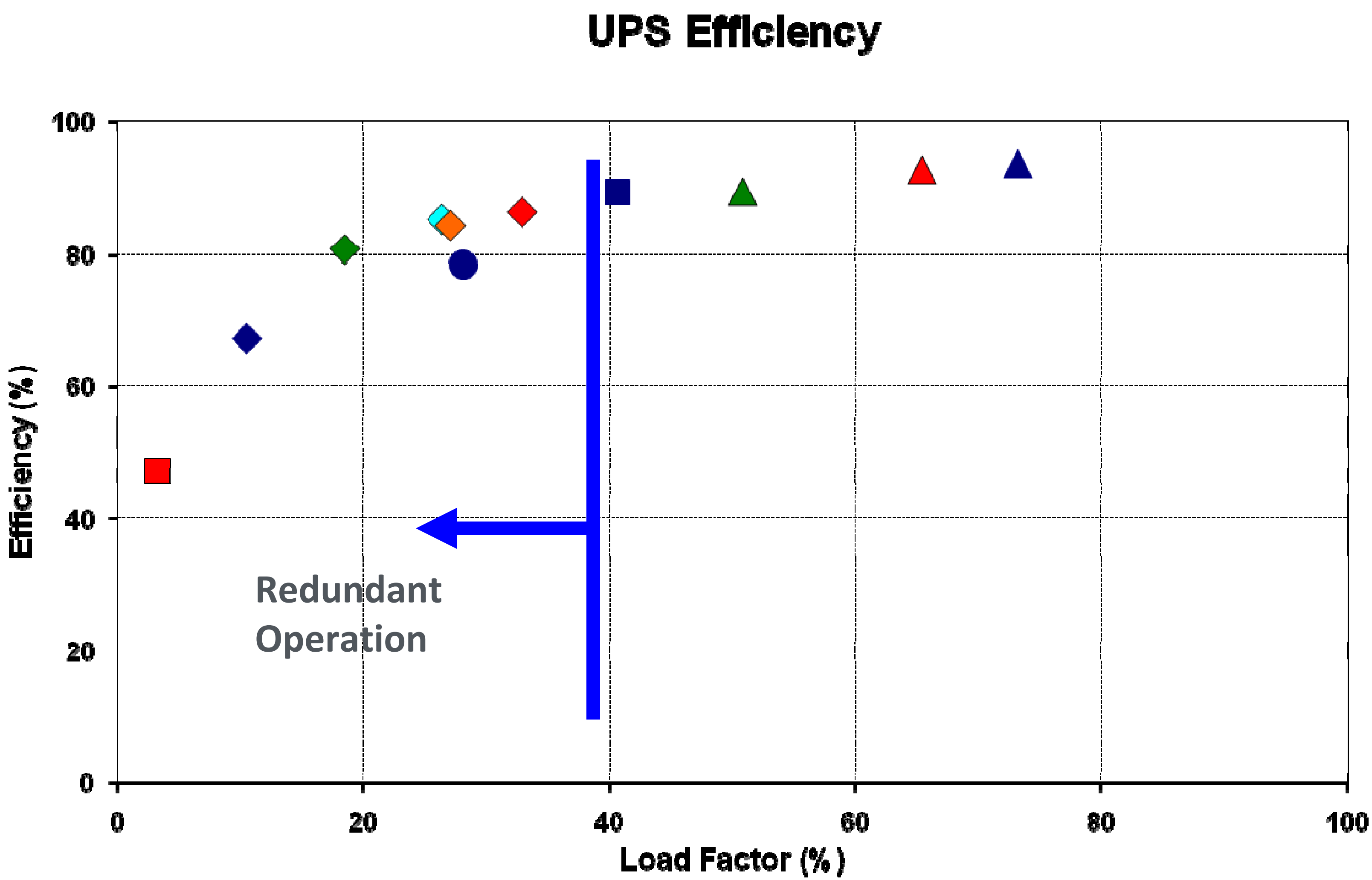
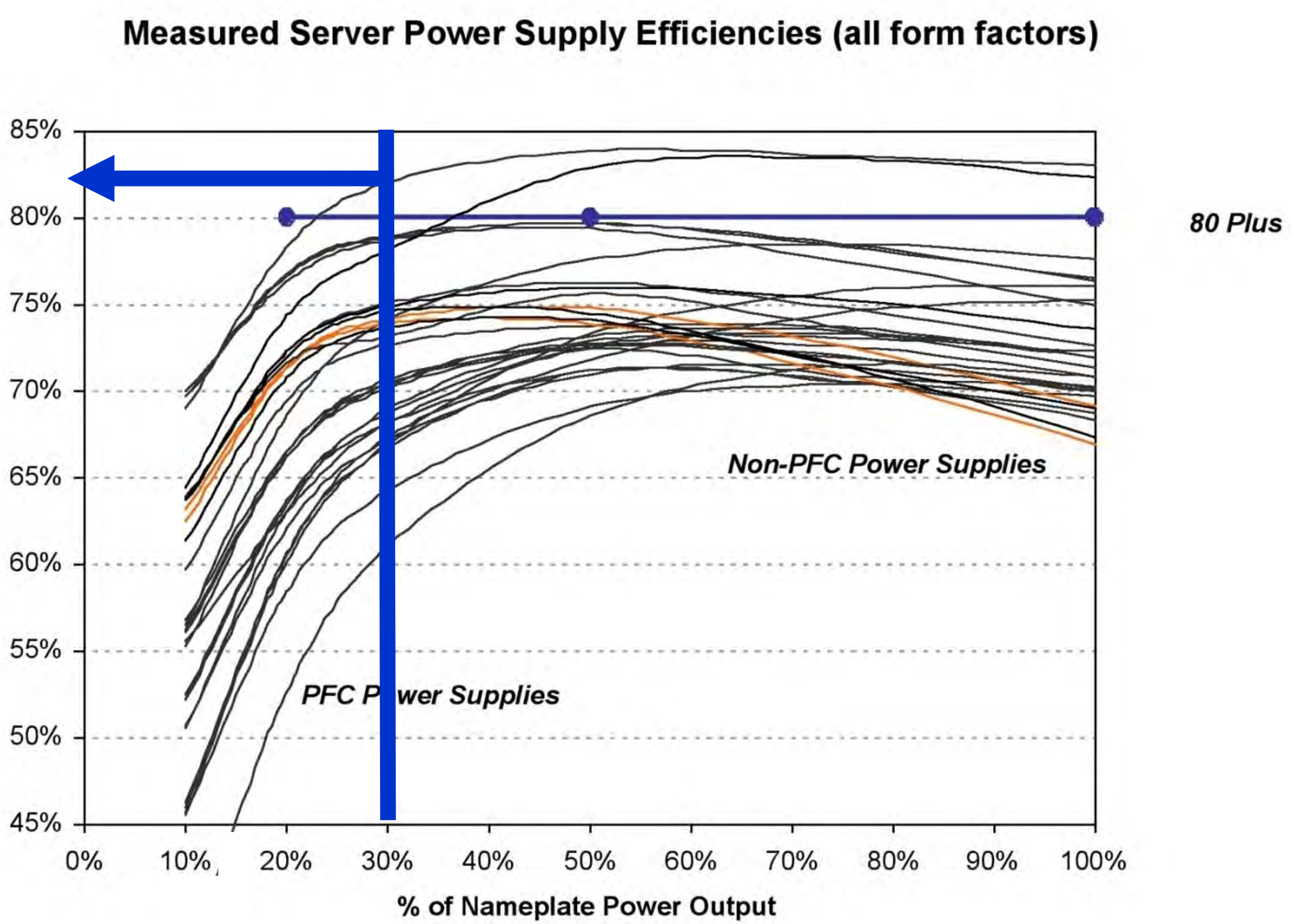
- Efficiencies vary with system design, equipment, and load
- Redundancies impact efficiency



Measured UPS efficiency



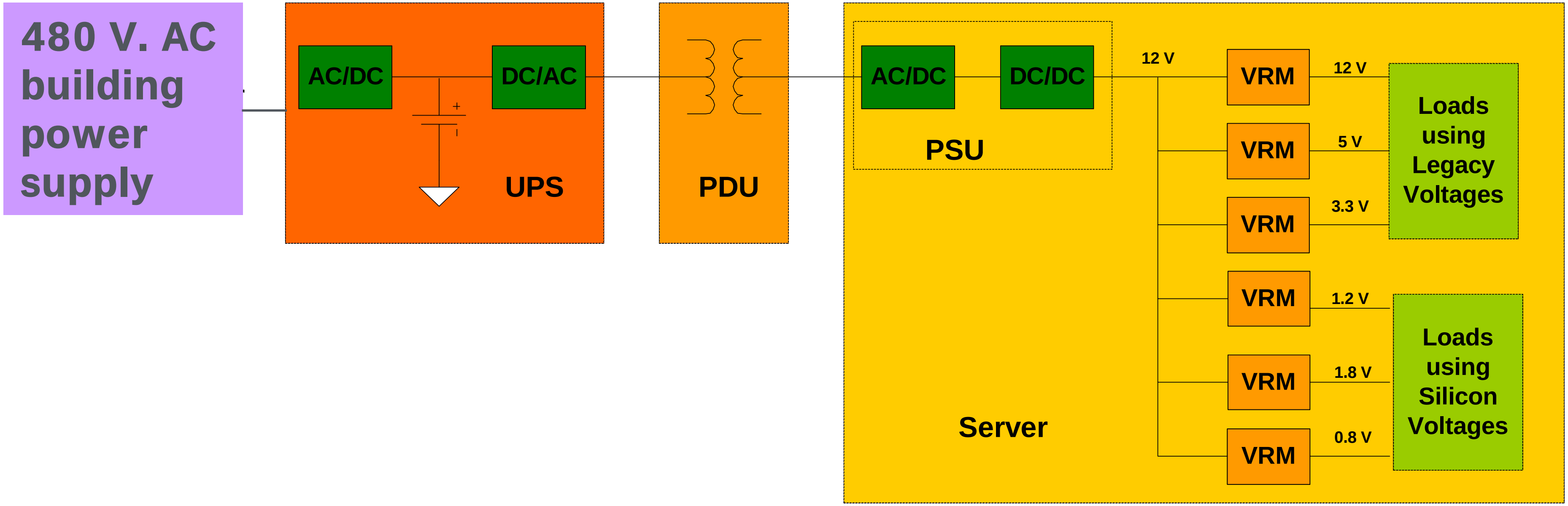
LBNL/EPRI measured power supply efficiency



Redundancy

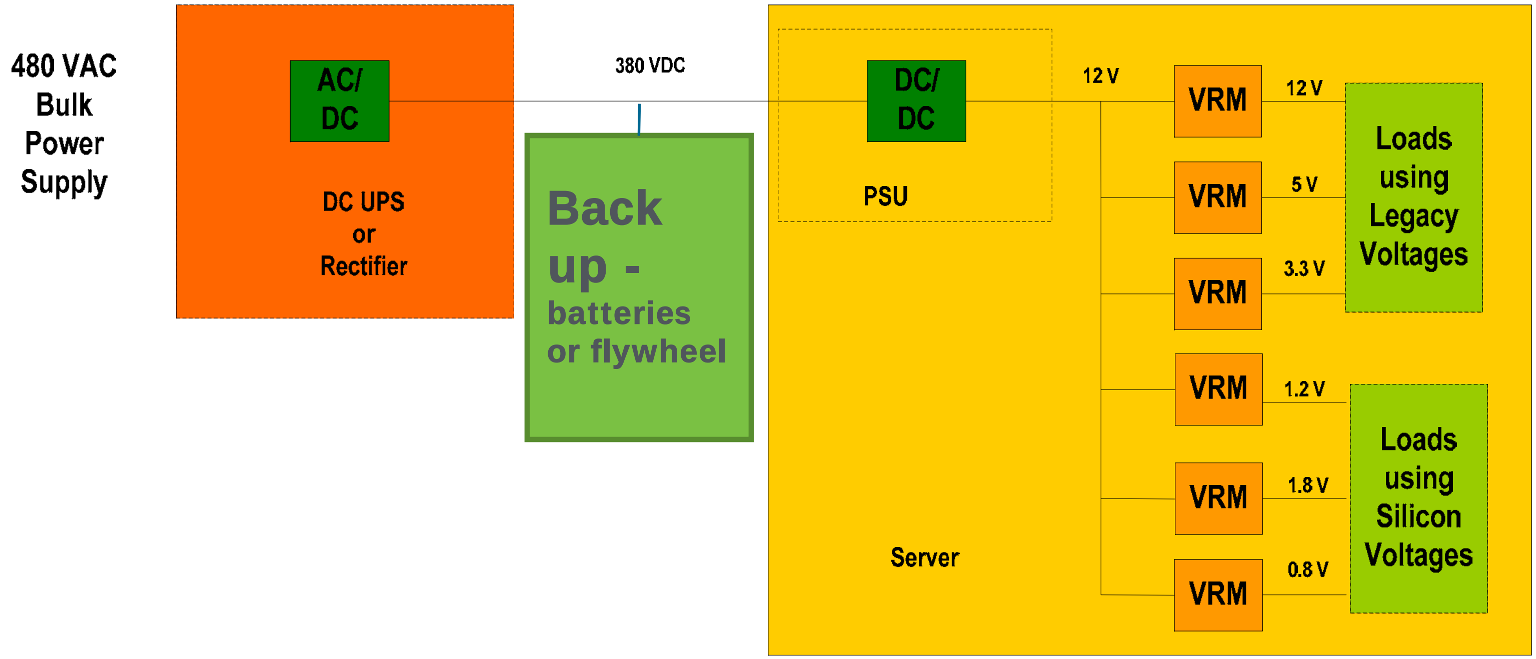
- Understand what redundancy costs and what it gets you – is it worth it?
- Does everything need the same level?
- Different strategies have different energy penalties (e.g. 2N vs. N+1)
- It's possible to more fully load UPS systems and achieve desired redundancy
- Redundancy in electrical distribution puts you down the efficiency curve

"Today's" AC distribution…



380V. DC power distribution

DC power can eliminate several stages of conversion and could be used for lighting, easy tie in of variable speed drives, and renewable energy sources.



Key Electrical Takeaways

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- **Choose highly efficient components and configurations**
- **Reduce power conversion (AC-DC, DC-AC, AC-AC, DC-DC)**
- **Consider the minimum redundancy required as efficiency decreases when systems are lightly loaded**
- **Use higher voltage**
- **Direct Current (DC) systems can reduce conversion losses.**

Resources and Workshop Summary

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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Federal Energy Management Program

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Federal Programs/Resources

Industrial Technologies Program
- Tool suite & metrics for baselining
- Training
- Qualified specialists
- Case studies
- Recognition of high energy savers
- R&D - technology development

Federal Energy Management Program
- Workshops
- Federal case studies
- Federal policy guidance
- Information exchange & outreach
- Access to financing opportunities
- Technical assistance

GSA
- Workshops
- Quick Start Efficiency Guide
- Technical Assistance

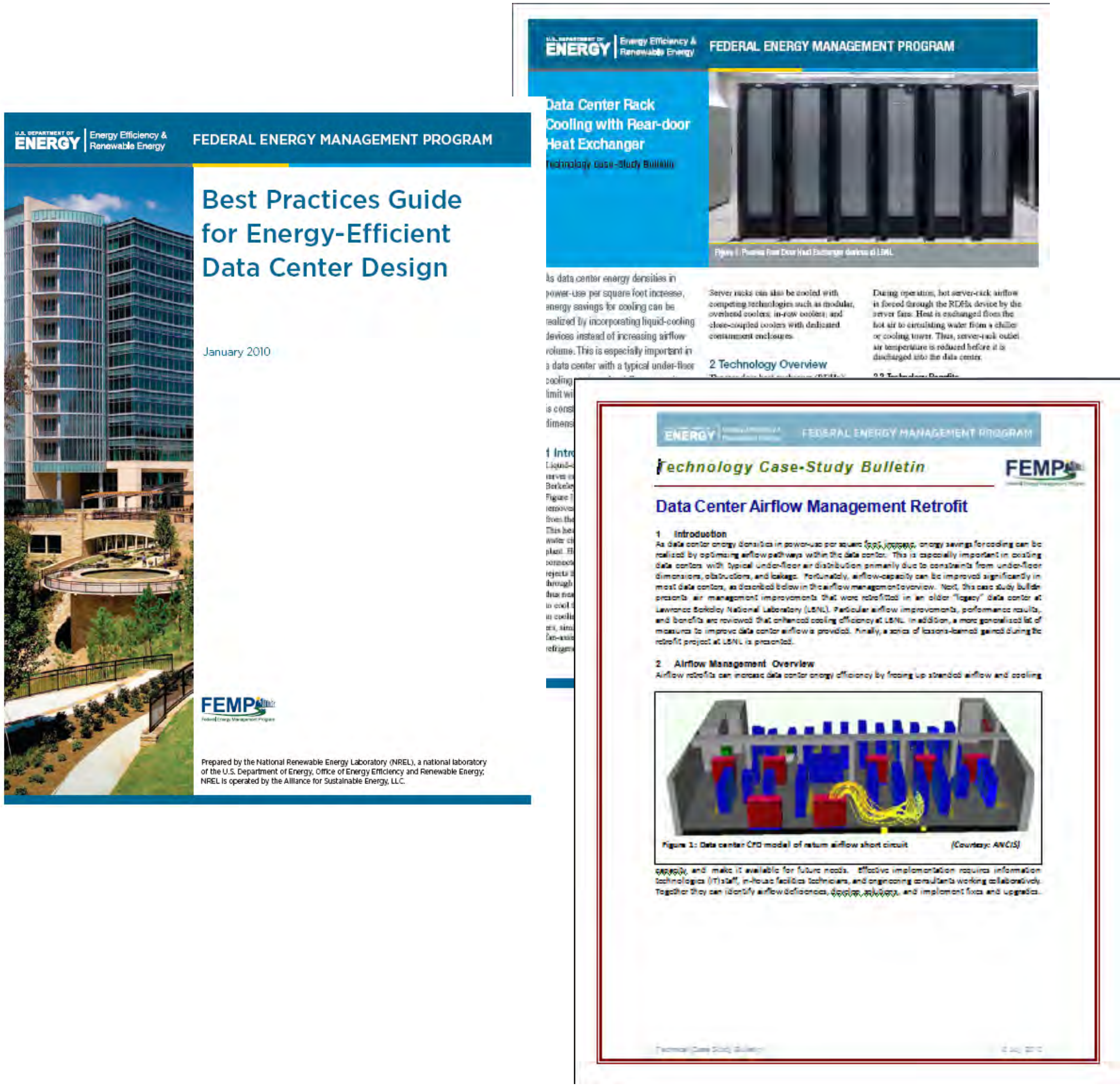
Industry
- Tools
- Metrics
- Training
- Best practice information
- Best-in-Class guidelines
- IT work productivity standard

EPA
- Metrics
- Server performance rating & ENERGY STAR label
- Data center benchmarking

Federal Data Center Resources

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Best Practices Guide
- Benchmarking Guide
- Data Center Programming Guide
- Technology Case Study Bulletins
- Procurement Specifications
- Report Templates
- Process Manuals
- Quick-Start Guide



FEMP Support for Data Center Energy Efficiency

FEMP in partnership with GSA and other agencies supports data center efficiency in the Federal sector:

- Technical Assistance
  - Implementation of DC Pro Tool Suite for benchmarking and assessments
  - Project planning and early design
  - Technology demonstration projects
- Training
  - Webinars
  - Workshops
- Development of tools and resources
- Access to funding sources
  - Energy savings performance contracts
  - Utility energy savings contracts
- Federal Energy Management Program awards

Data Center Working Groups

The Federal Partnership for Green Data Centers

- **An Inter-Agency forum to exchange ideas, develop policy guidance & tools to improve data center performance**

High Performance Computing Working Group

- **A forum for sharing information on best practices in scientific computing**
- **Includes members from the public and private sectors**

DOE Adnvanced Manufacturing Office (AMO - was ITP)

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DOE's AMO data center program provides tools and resources to help owners and operators:

- **DC Pro Software Tool Suite**
  - Tools to define baseline energy use and identify energy-saving opportunities
  - **Information products**
  - Manuals, case studies, and other resources to identify and reduce operating costs, and regain data center infrastructure capacity
- **End-user awareness training**
  - Workshops in conjunction with ASHRAE
- **Data Center Energy Practitioner (DCEP) certificate program**
  - Qualification of professionals to evaluate energy efficiency opportunities
- **Research, development, and demonstration of advanced technologies**

DOE DC Pro Tool Suite

High-Level On-Line Profiling and Tracking Tool

- Overall efficiency (Power Usage Effectiveness [PUE])
- End-use breakout
- Potential areas for energy efficiency improvement
- Overall energy use reduction potential

In-Depth Assessment Tools → Savings

Air Management
- Hot/cold separation
- Environmental conditions
- RCI and RTI

Electrical Systems
- UPS
- PDU
- Transformers
- Lighting
- Standby gen.

IT-Equipment
- Servers
- Storage & networking
- Software

Cooling
- Air handlers/ conditioners
- Chillers, pumps, fans
- Free cooling

Data Center Energy Practitioner (DCEP) Program

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A certificate process for energy practitioners qualified to evaluate energy consumption and efficiency opportunities in Data Centers.

Key objective:

•Raise the standards of assesors

•Provide greater repeatability and credibility of recommendations.

Target groups include:

•Data Center personnel (in-house experts)

•Consulting professionals (for-fee consultants)

What is ENERGY STAR?

A voluntary public-private partnership program

- Buildings
- Products

ENERGY STAR

Resources

FEMP Federal Energy Management Program http://www1.eere.energy.gov/femp/program/data_center.html

Berkeley Lab http://hightech.lbl.gov/datacenters.html

Energy Star http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

Save Energy Now® http://www1.eere.energy.gov/industry/datacenters/

Data Center Best Practices Summary

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1. Measure and Benchmark Energy Use
2. Identify IT Opportunities
3. Use IT to Control IT
4. Manage Airflow
5. Optimize Environmental Conditions
6. Evaluate Cooling Options
7. Improve Electrical Efficiency
8. Implement Energy Efficiency Measures

Most importantly…

Get IT and Facilities People Talking and working together as a team!!!

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Lawrence Berkeley National Laboratory A-Team
Energy Efficient Building Design Applications

FEMP
Federal Energy Management Program