U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

How to Save Money In Your Small Data Center

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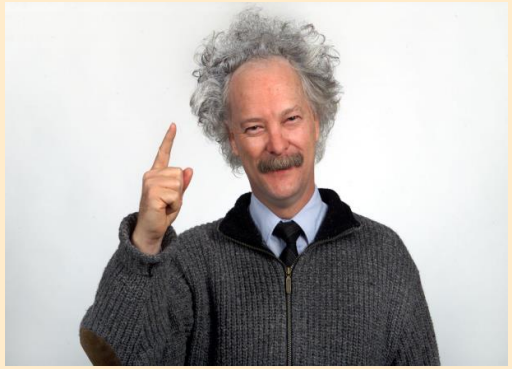
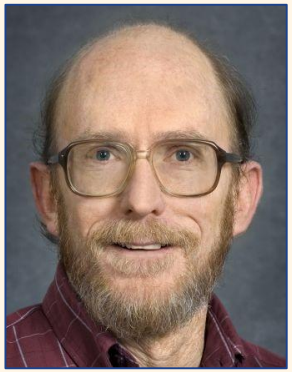
DATE 08/20/2018

FEMP Federal Energy Management Program

Today's Presenters

Name		Organization
Dale Sartor, P.E.		LBNL
Steve Greenberg, P.E.		LBNL

Download Presentation – Next Week

This Presentation is Available for download at:

http://datacenterworkshop.lbl.gov/

Agenda

- Why small data centers are important
- Simplest Measures
  - Information Technology (IT)
  - Cooling
  - Electrical distribution
- Still simple, a little more work
  - IT refresh and virtualization
- Break
- Higher-level investment, but very cost-effective
  - Move data center functions elsewhere
  - Implement IT and infrastructure power monitoring
  - Capital upgrades to cooling system
- Training for IT and Facility Staff
- Resources

Why Small Data Centers are Important

- Definition: “Small” is less than 5,000 square feet of computer floor
- Have nearly half of the total servers
- Use 40 billion kWh/yr in the US (~$4 billion)
- Embedded data centers often dominate the entire building’s energy use even though they are a small fraction of the total floor area
- Have challenges in terms of good management:
  - Typically no one person in charge, and no one’s full-time job
  - Security risks
  - Computing and supporting infrastructure energy not monitored
- Have large energy-saving opportunities, typically 20 – 40%. 30% savings would result in ~$1 billion per year in savings, across US data center industry.
- Not exempt from Data Center Optimization Initiative

Data Center Optimization Initiative (DCOI)

Specific goals for data centers:

- Promote energy optimization, efficiency, and performance
- Installing and monitoring advanced energy meters in all data centers by fiscal year 2018
- Establishing a Power Usage Effectiveness (PUE) target of 1.2 to 1.4 for new data centers and less than 1.5 for existing data centers.

Run by OMB and GSA

https://datacenters.cio.gov/

Simplest Measures

- Turn off unused servers
- Improve server power management
- Improve air management
- Increase temperature setpoints toward the high end of the range set by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE)
- Turn off active humidity control
- Minimize requirements for Uninterruptible Power Supplies (UPS)

Turn off unused servers

- Known as “comatose” or “zombie” servers: they do no useful work, but use
  - Power
  - Space
  - Cooling
- Estimated 20-30% of servers are comatose
- An idle server uses
  - ~50% of full-load power (100% utilization)
  - ~75% of typical load power (25% utilization)

What to do:

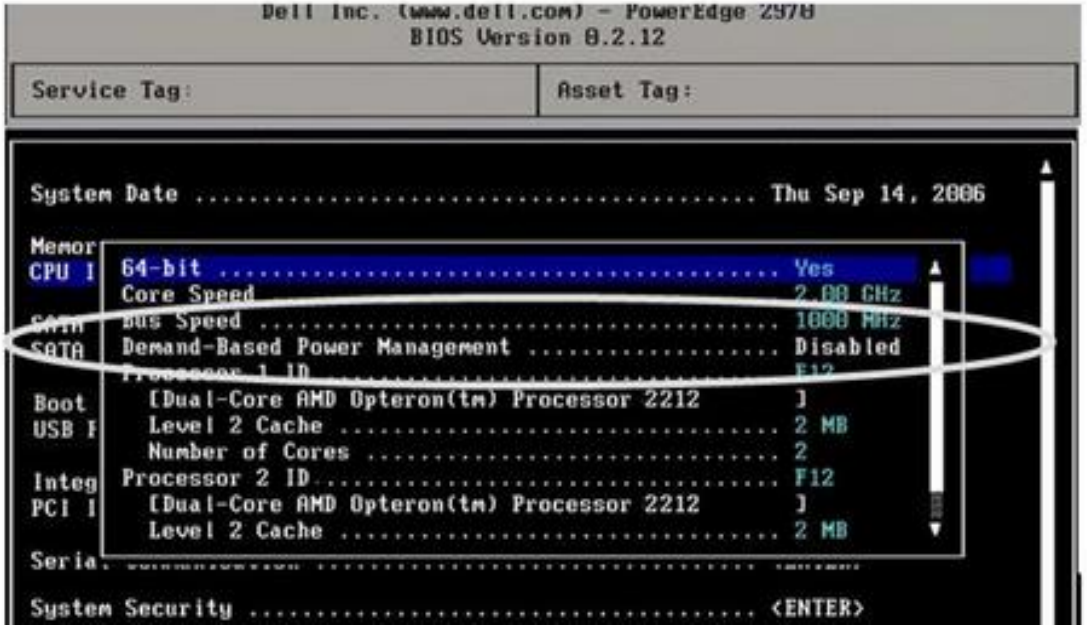
- Establish and maintain a list of what’s running on each machine
- Shut down unused servers

Improve server power management

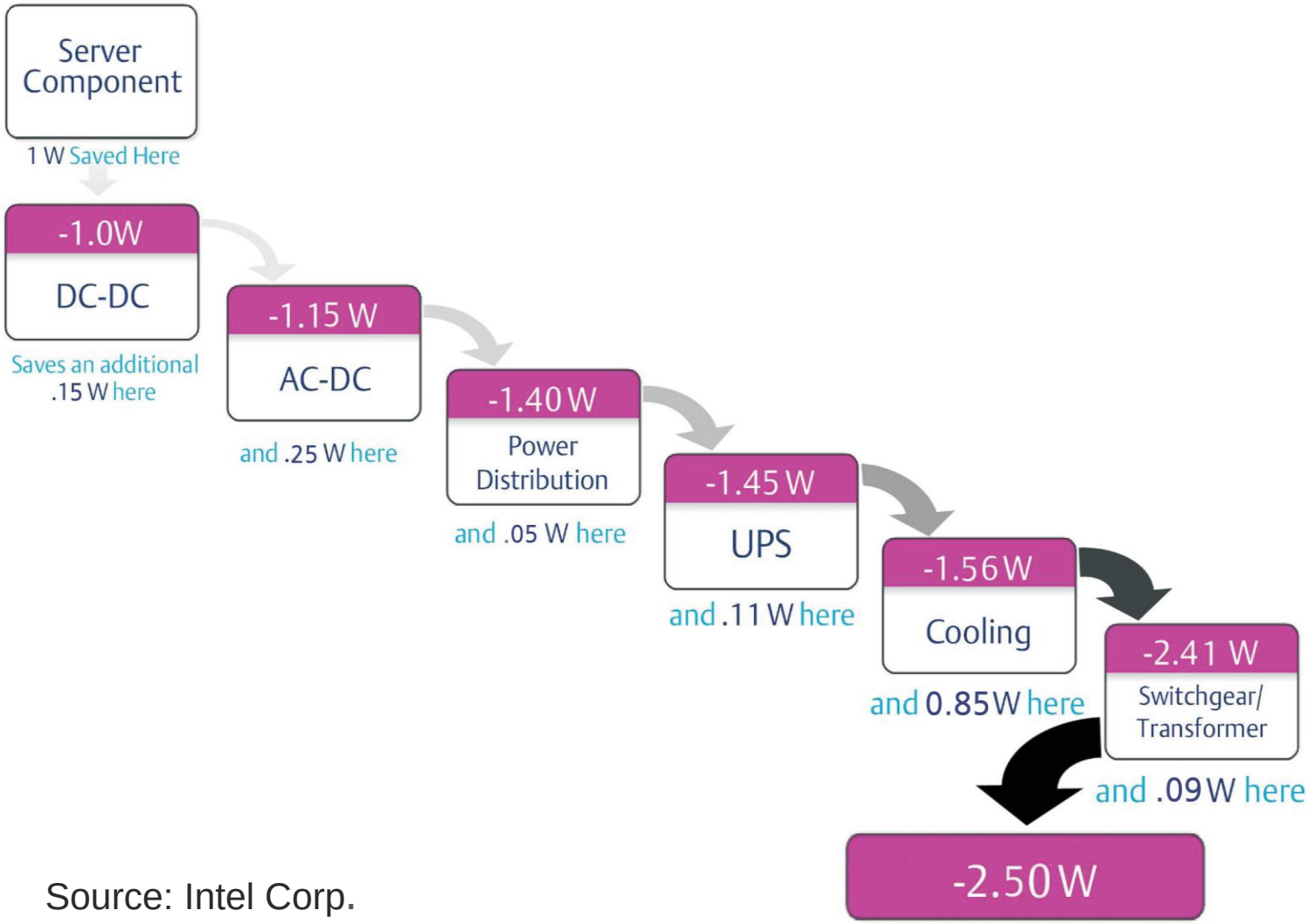
- Most servers are shipped with power management turned on
- Most servers in use have power management turned off

What to do:

- Check power management settings and enable
  - Processor
  - OS (Operating System) /hypervisor
  - BIOS (Basic Input/ Output System)



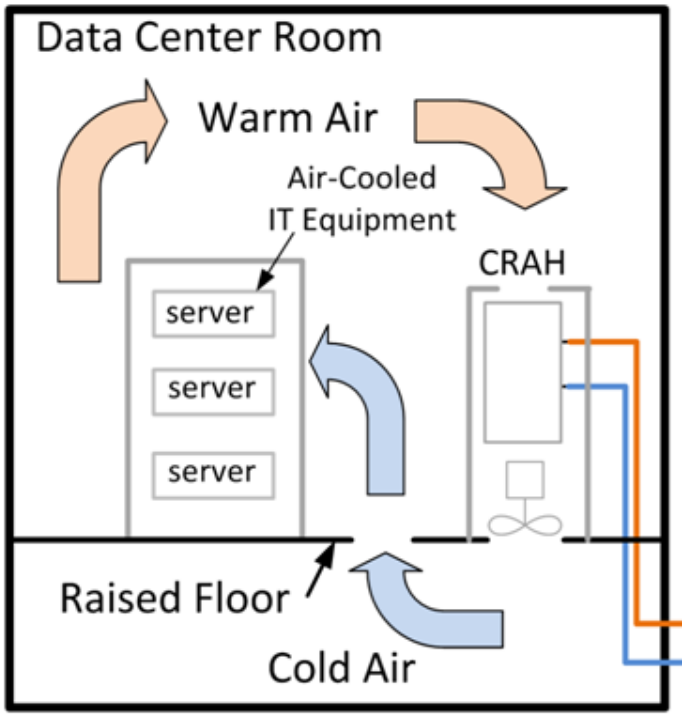
Actual Saving of One Watt Saved at the IT Equipment

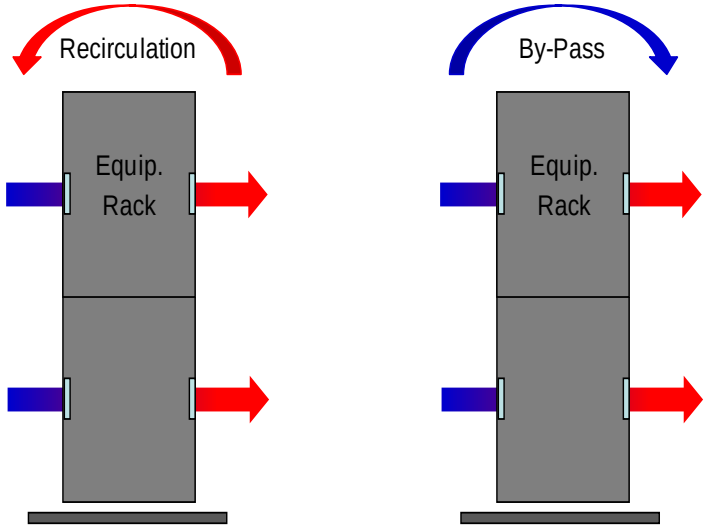


Source: Intel Corp.

Improve air management

- Cool supply air *ideally* gets from cooling equipment to the Information Technology (IT) inlet without mixing with hot discharge air
- Hot discharge air *ideally* returns from the IT exhaust to the cooling equipment without mixing with the cool supply air

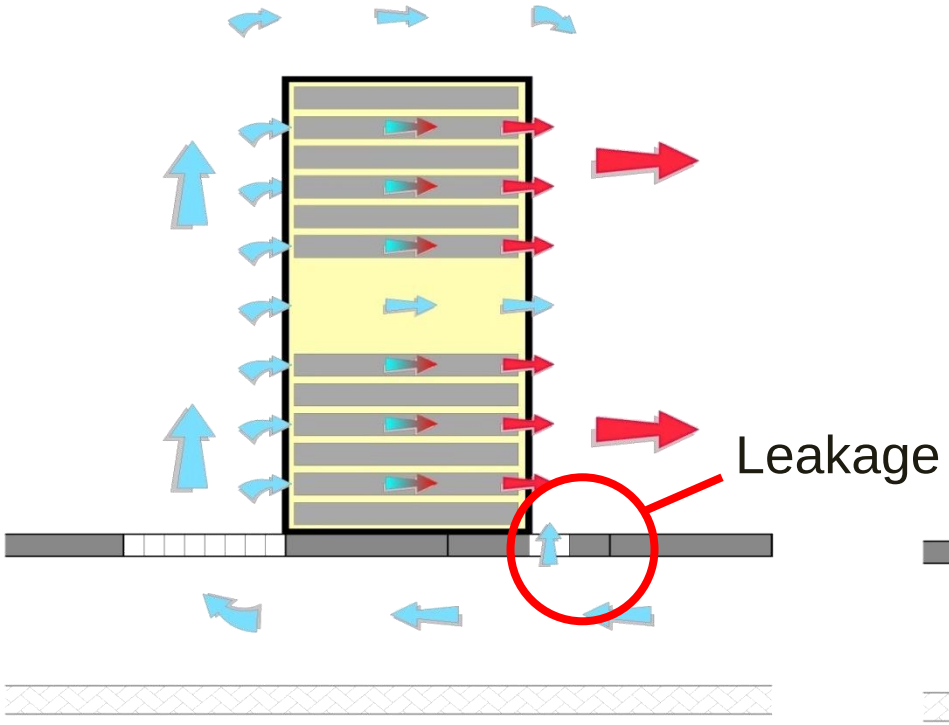




Note: CRAH (Computer Room Air Handler) is the cooling equipment

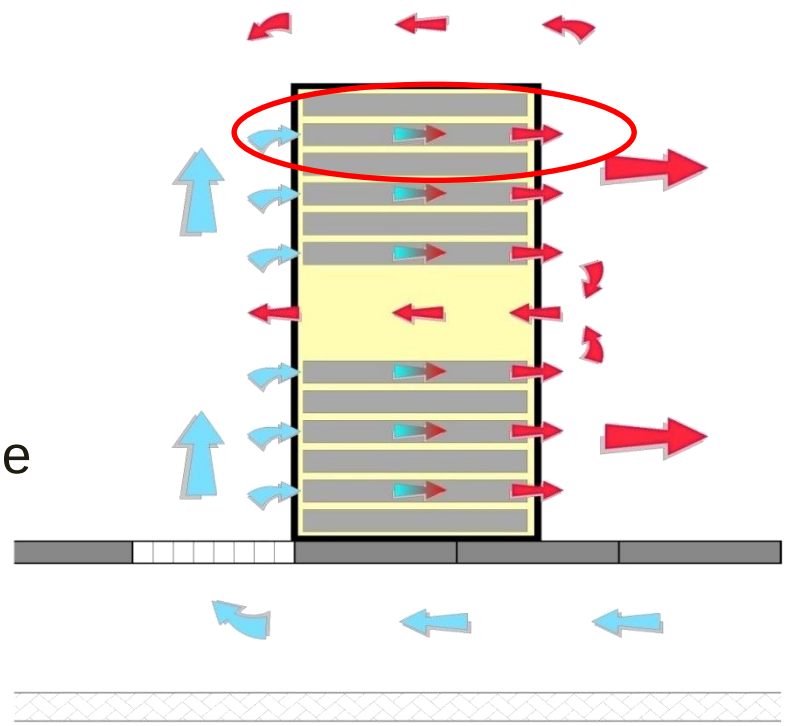
Reduce By-Pass and Recirculation Air

Bypass Air / Short-Circuiting



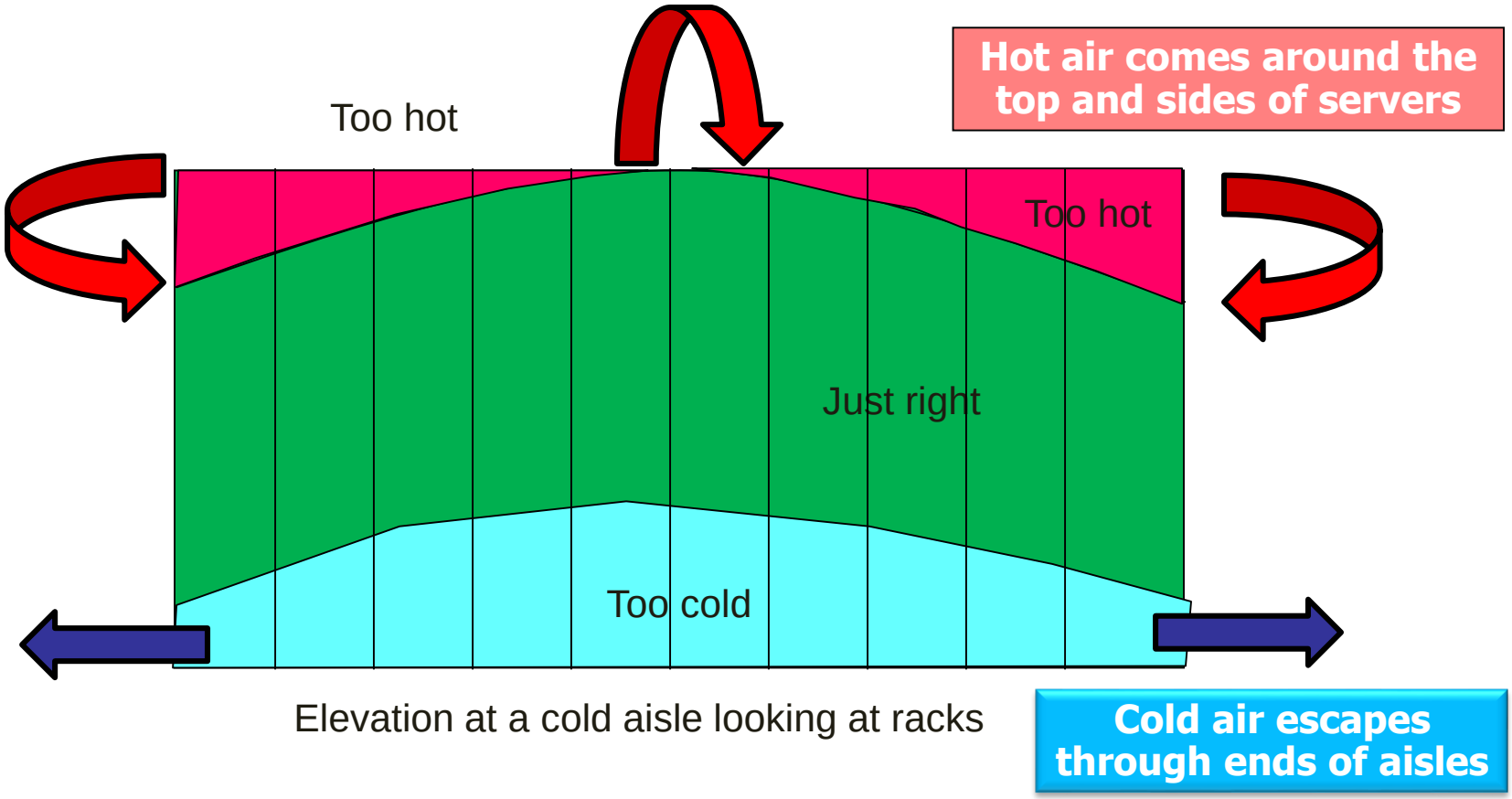
Wastes fan energy as well as cooling energy and capacity

Recirculation



Increases inlet temperature to servers

Typical Temperature Profile with Under-floor Supply



There are numerous references in ASHRAE.
See for example V. Sorell et al; "Comparison of Overhead and Underfloor Air Delivery Systems in a Data Center Environment Using CFD Modeling"; ASHRAE Symposium Paper DE-05-11-5; 2005.

Improve air management, con't

What to do:

- Clear the desired air path (e.g. abandoned and cluttered cables)
- Block the undesirable air paths
  - Within and between racks
  - Cable and conduit cutouts from under floor and into ceiling plenum
  - Rack tops and row ends

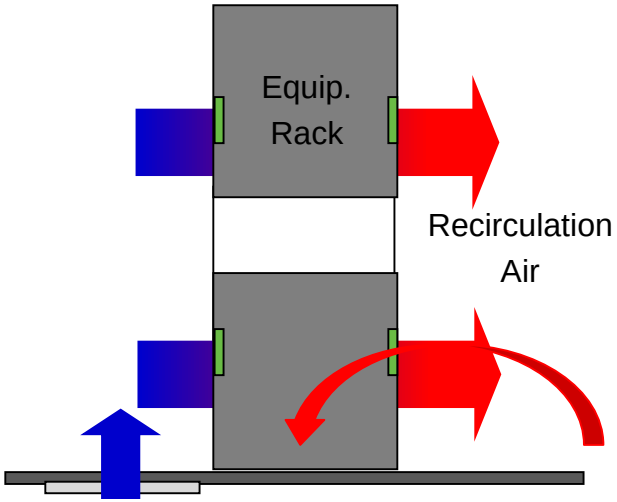
Pictures courtesy of ANCIS Incorporated

Benefits:

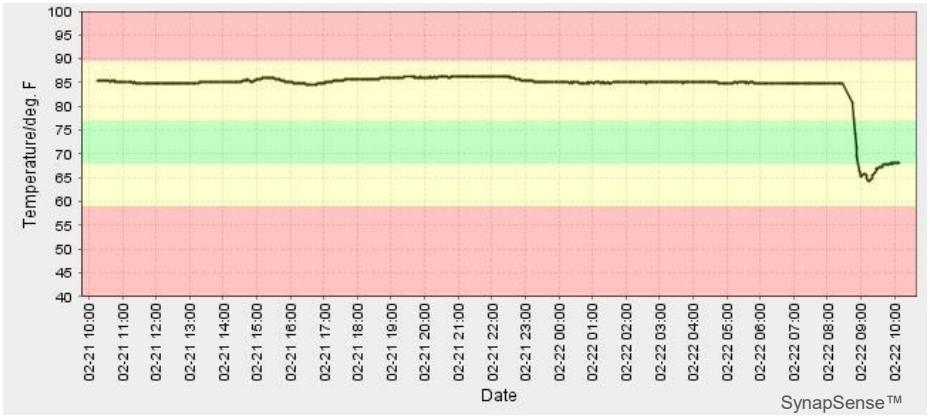
- Allows increased supply air temperature (reduced cooling energy)
- Allows reduced air flow (reduced fan energy)

Air Management: Blanking Panels

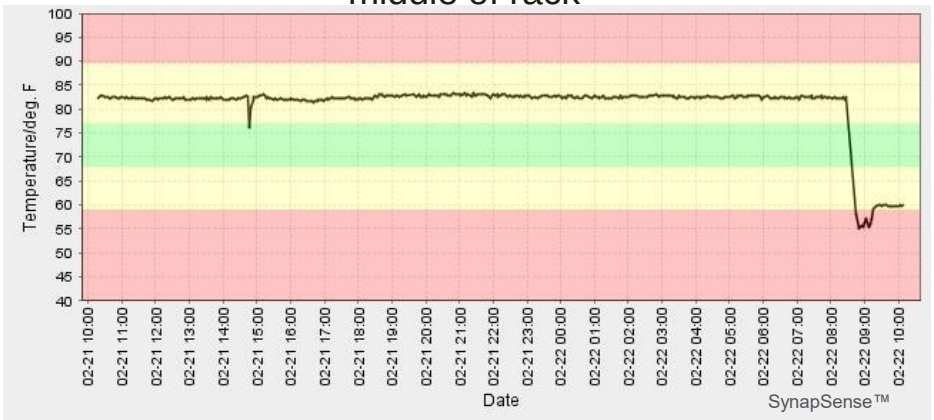
- Any opening will degrade the separation of hot and cold air
- Maintain blanking panels
  - One 12" blanking panel reduced temperature ~20°F



top of rack

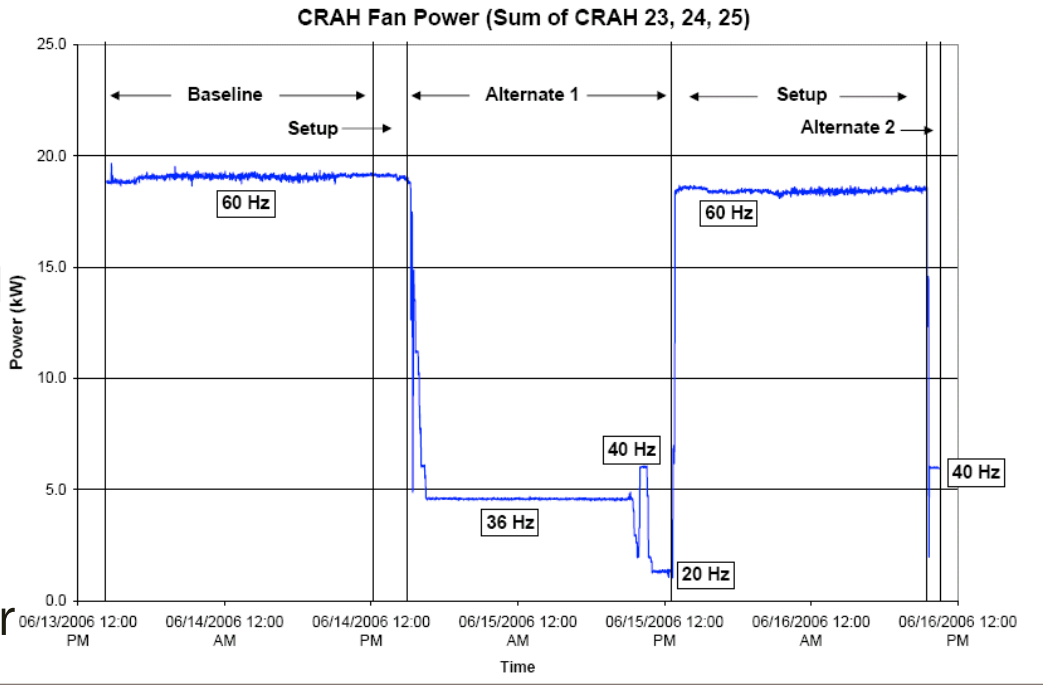


middle of rack



Air Management: Fan Energy Savings

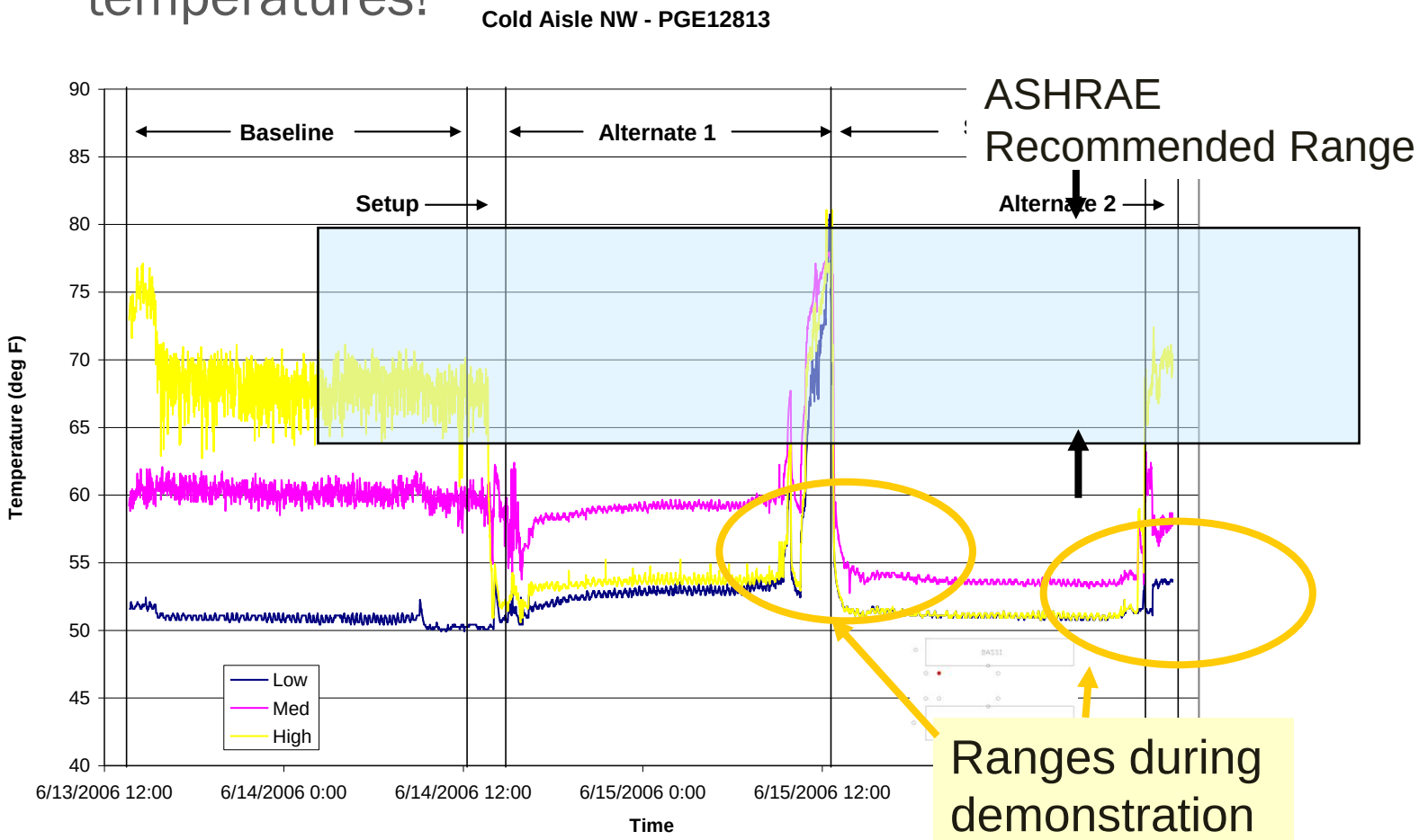
- Isolation significantly reduces bypass air, which in turn allows reduction of supply airflow
- Fan speed can be reduced, and fan power is proportional to nearly the cube of the flow
- Fan energy savings of 70%–80% is possible with variable air volume (VAV) fans



Without Enclosure With Enclosure Without Enclosure

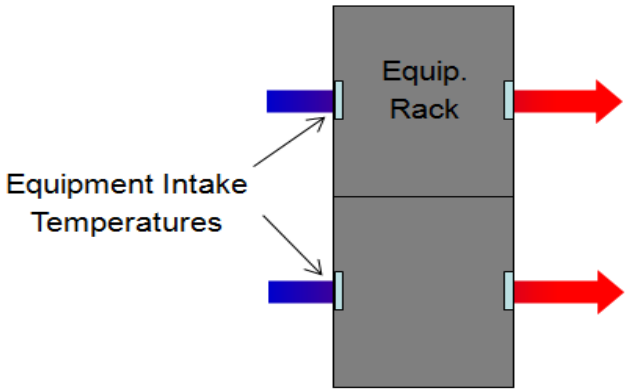
LBNL Air Management Demonstration

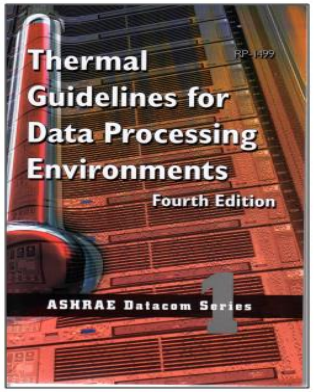
Better airflow management permits warmer supply temperatures!



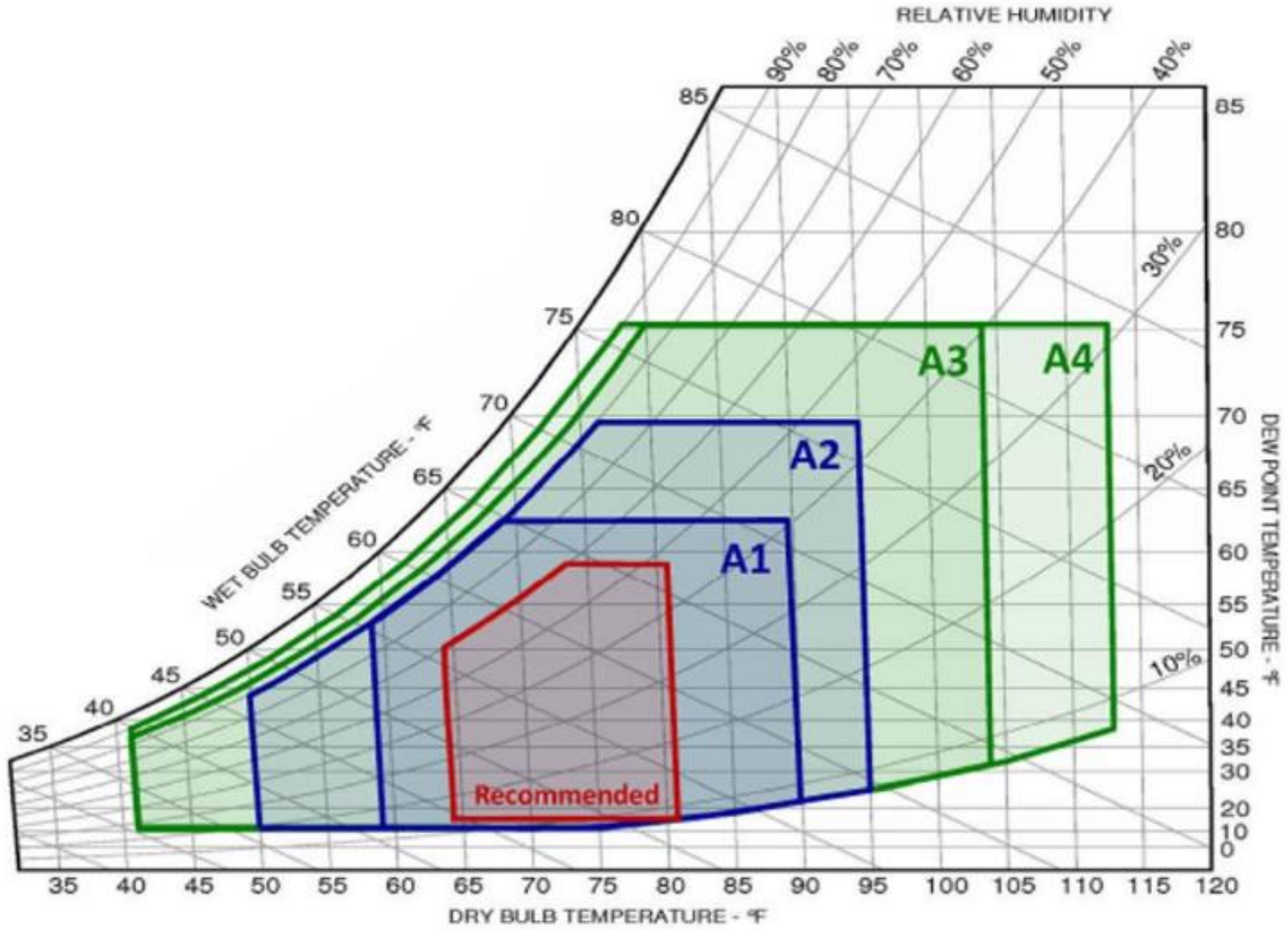
Increase air temperature setpoints toward the high end of the ASHRAE range

- IT *inlet* temperature is what matters
- ASHRAE ranges:
  - Recommended range (rounded): 65 to 80° F
  - Allowable ranges (A1 - A4): 59 to 90° F (A1) … 41 to 113° F (A4)
- NOT the same as the temperature setpoint for the CRAC (Computer Room Air Conditioner) or CRAH (Computer Room Air Handler), especially for units controlled on return air
- Ensure good air management first before changing control setpoints to avoid hotspots
- Enables savings in chiller or CRAC compressor energy





2015 ASHRAE Temperature and Humidity Ranges



Turn off active humidity control

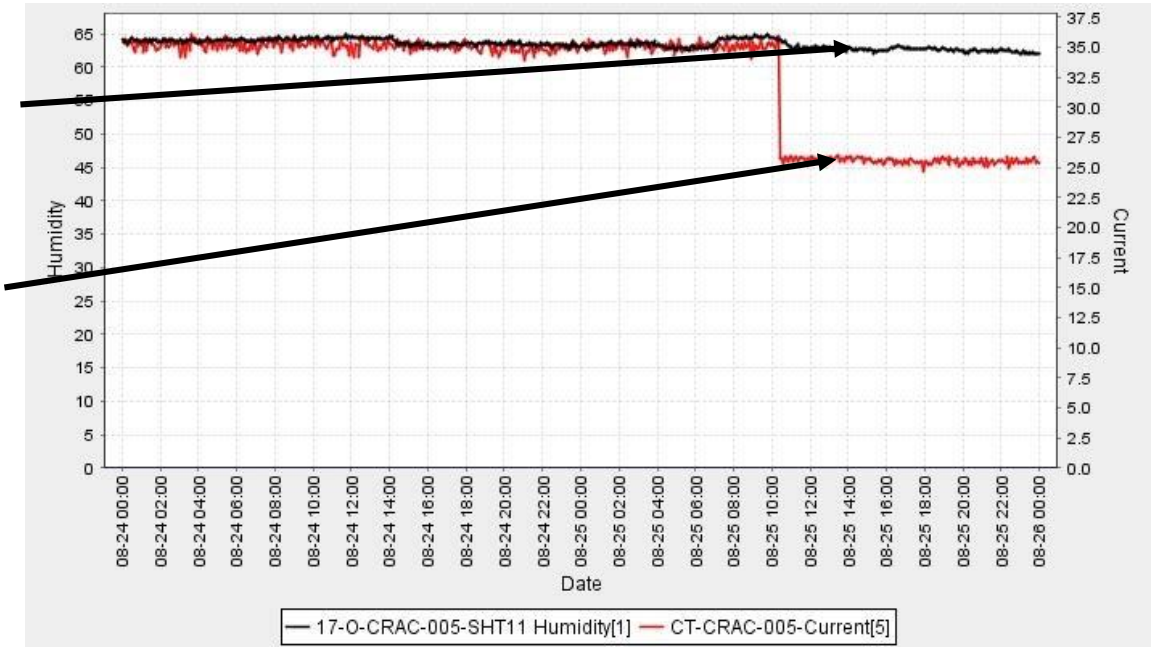
- **Wider ASHRAE range (as of 2015, and retroactive) means that little if any control is required**
- **Recommended range: 15.8° to 59° F dewpoint temperature (a measure of absolute humidity) and 60% RH (relative humidity) at the IT inlet**
- **CRACs and CRAHs are often set**
  - to 45-55% RH (much too tight)
  - based on the return air (rather than IT inlet or supply air)
- **Adjusting setpoints or turning off humidity control results in:**
  - Humidification savings
  - Dehumidification savings
  - Often both
  - 28% cooling savings at LBNL - eliminated humidity control

The Cost of Unnecessary Humidification

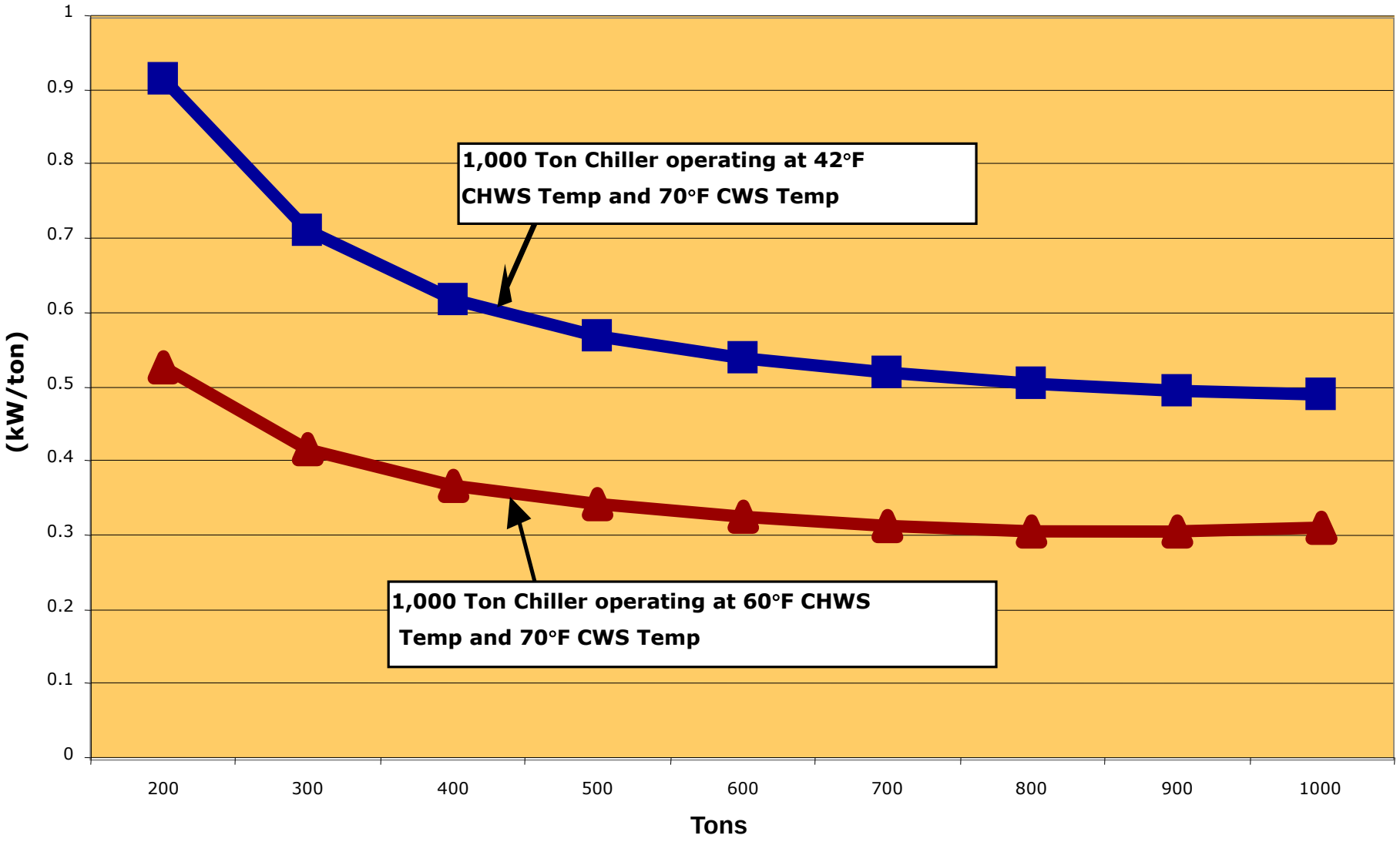
	Visalia Probe			CRAC Unit Panel			
	Temp	RH	Tdp	Temp	RH	Tdp	Mode
AC005	84.0	27.5	47.0	76	32.0	44.1	Cooling
AC006	81.8	28.5	46.1	55	51.0	37.2	Cooling & Dehumidification
AC007	72.8	38.5	46.1	70	47.0	48.9	Cooling
AC008	80.0	31.5	47.2	74	43.0	50.2	Cooling & Humidification
AC010	77.5	32.8	46.1	68	45.0	45.9	Cooling
AC011	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%



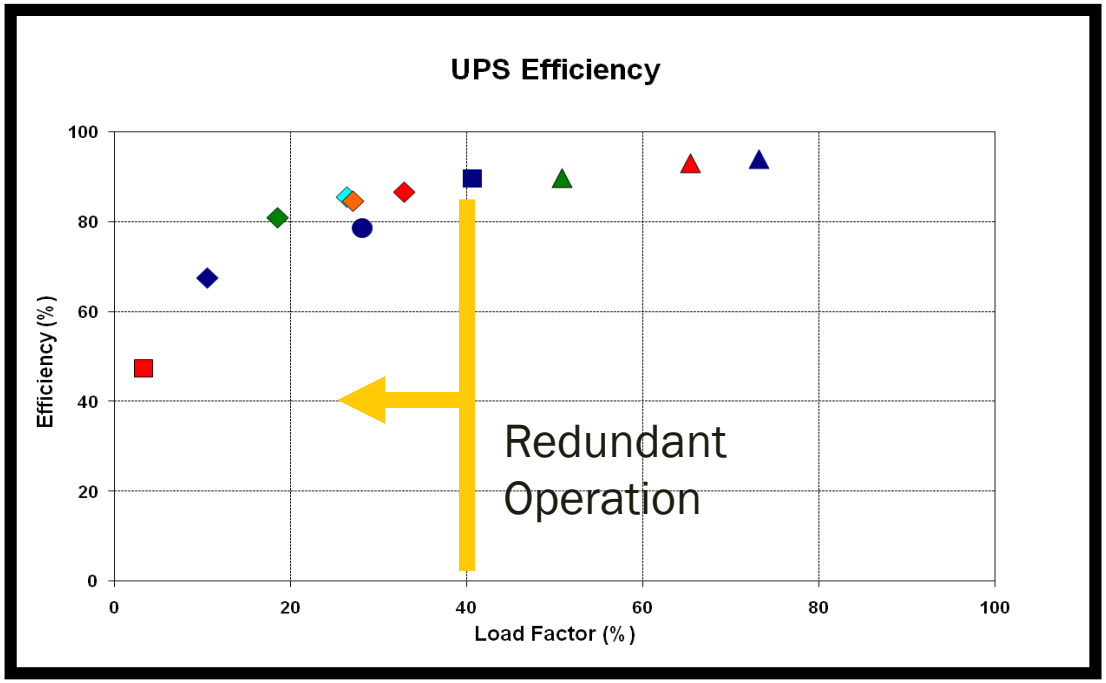
Increase Temperature of Chilled Water



Data provided by York International Corporation

Minimize Uninterruptible Power Supply (UPS) requirements

- Unnecessary redundancy leads to inefficiency
- Many applications can be shut down and restarted without adverse effects
- Critical applications should be considered for moving to a larger data center or the cloud
- Analyze UPS needs
  - Minimize number and size
  - Use ENERGY STAR UPS units
  - Use Eco-mode
  - Savings can range from ~10 - 50% of IT load



Source: LBNL Benchmarking study

Questions

Still simple, a little more work

- Refresh the oldest IT equipment with new high-efficiency equipment
- Consolidate and virtualize applications

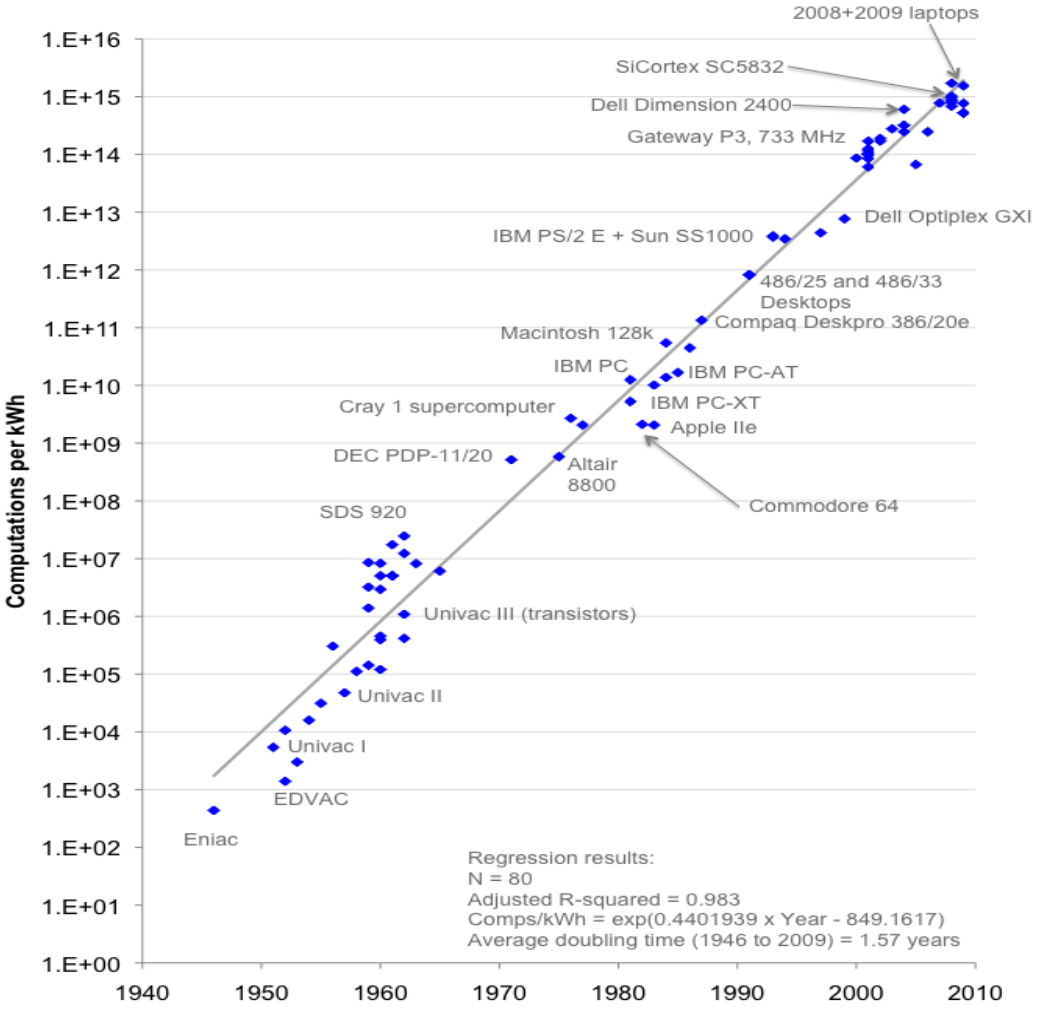
Refresh the oldest IT equipment with new high-efficiency equipment

- New equipment is more powerful and gets more computing per watt plus better power management
- More virtualization potential
- Energy and software cost savings typically justifies a faster refresh rate

What to do – Procure:

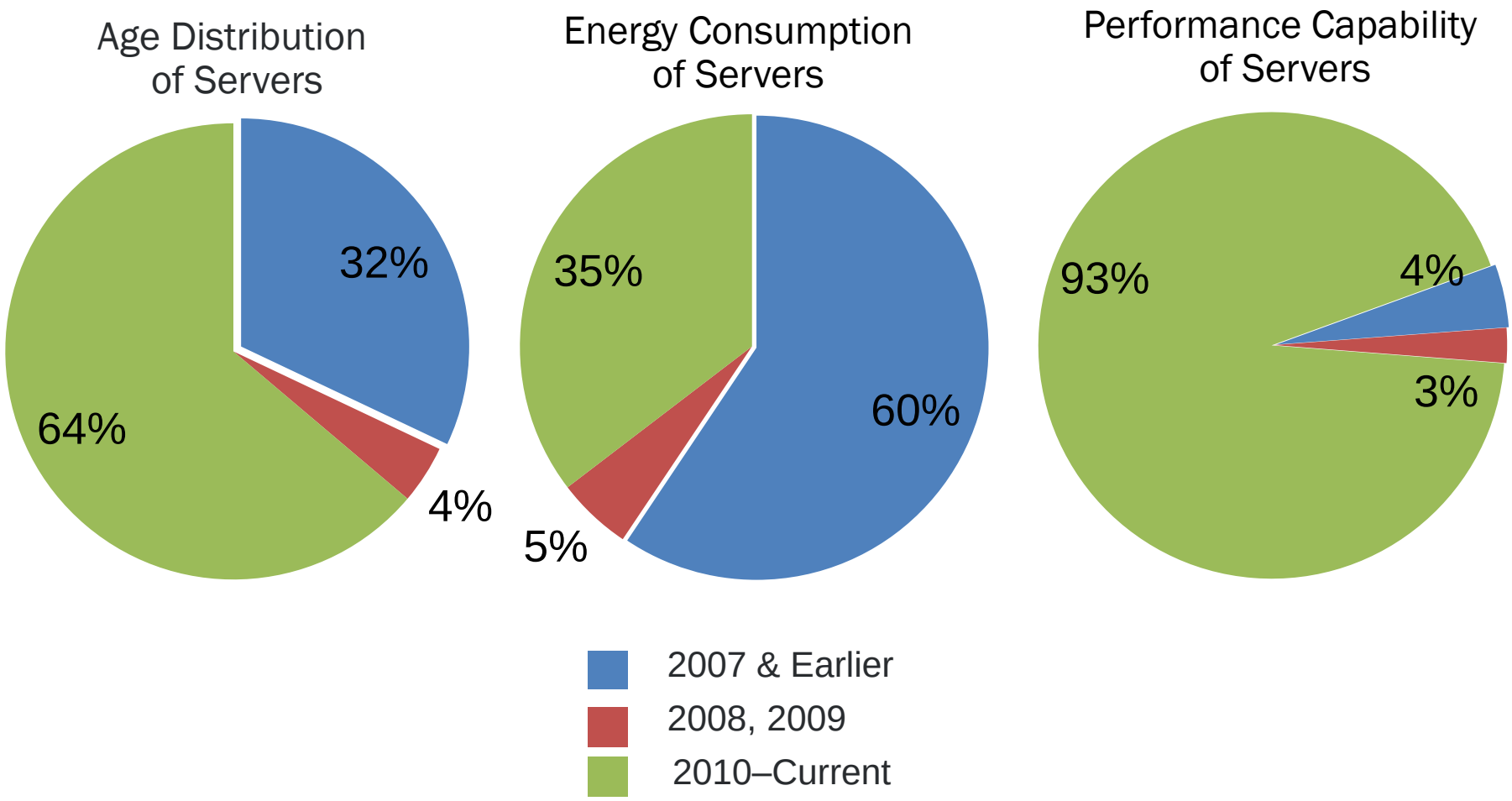
- ENERGY STAR
  - Servers
  - Networking equipment
  - Storage
- Solid-state drives (vs. hard disks)
- 80-Plus power supplies (ENERGY STAR requirement)
  - ~5-20% savings possible with more efficient power supplies

Computing Efficiency Increases 100x Every Decade



Source: Koomey et al. 2011

Old servers consume 60% of energy, but deliver only 4% of performance capability



Data collected at a Fortune 100 company; courtesy of John Kuzma and William Carter, Intel

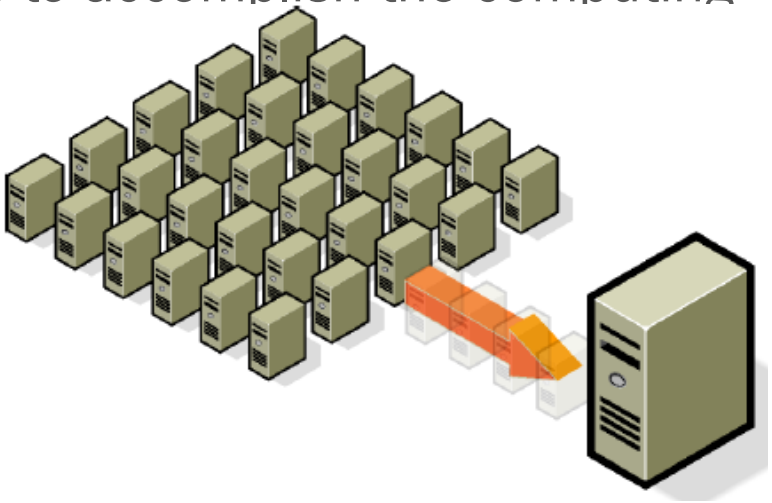
Use Efficient Power Supplies

80 PLUS Certification Levels

Level of Certification	Efficiency at Rated Load					
	115V Internal Non-Redundant			230V Internal Redundant		
	20%	50%	100%	20%	50%	100%
80 PLUS	80%	80%	80%	n/a	n/a	n/a
80 PLUS Bronze	82%	85%	82%	81%	85%	81%
80 PLUS Silver	85%	88%	85%	85%	89%	85%
80 PLUS Gold	87%	90%	87%	88%	92%	88%
80 PLUS Platinum	90%	92%	89%	90%	94%	91%
80 PLUS Titanium	92%	94%	90%	94%	96%	91%

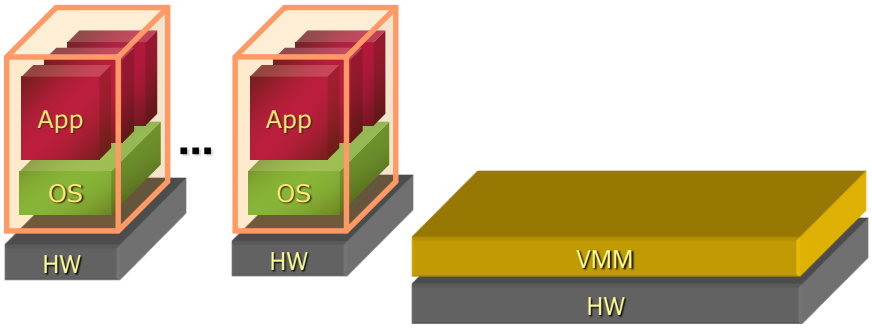
Consolidate and virtualize applications

- Most servers operate with very low utilization (5-15% on average)
- Servers at typical loads (5-15% utilization) use roughly 75% of average peak power
- Big opportunities:
  - Virtualization (running multiple software applications on one physical machine)
  - Consolidation (using fewer machines to accomplish the computing task)
- Energy savings from power and cooling reductions
- Space savings



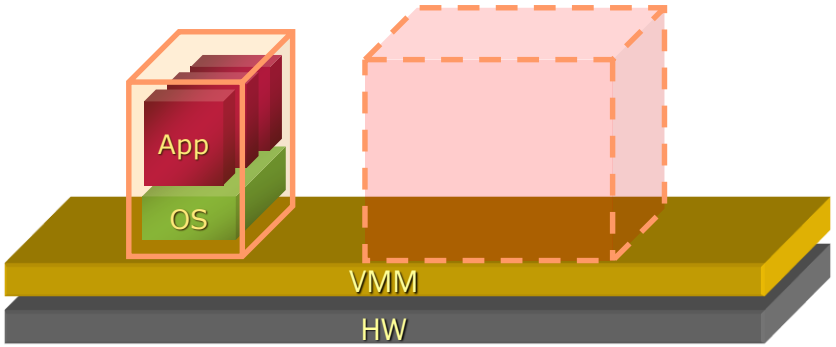
Virtualization : Workload provisioning

Server Consolidation



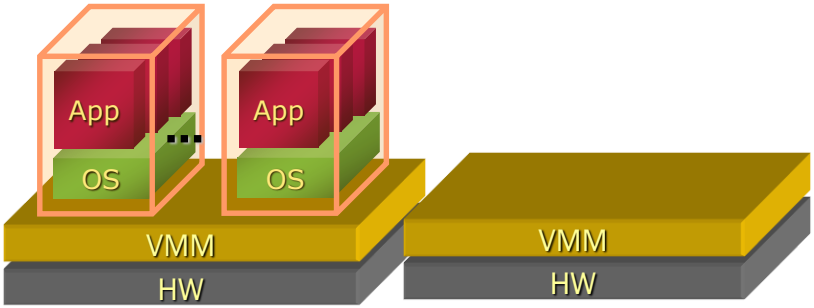
10:1 in many cases

R&D Production



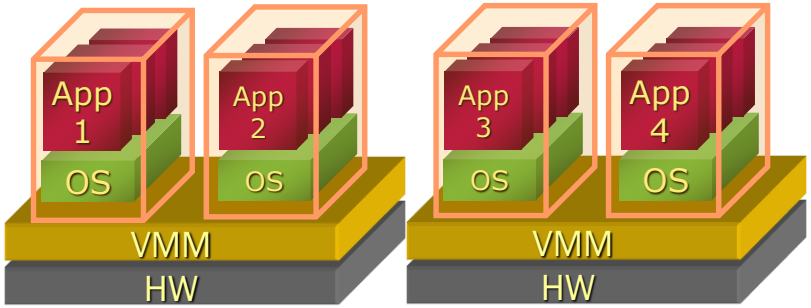
Enables rapid deployment, reducing number of idle, staged servers

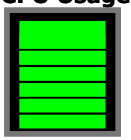
Disaster Recovery



Upholding high-levels of business continuity. One Standby for many production servers.

Dynamic Load Balancing





Balancing utilization with head room

Questions

Higher-Level Investment, but Very Cost-Effective

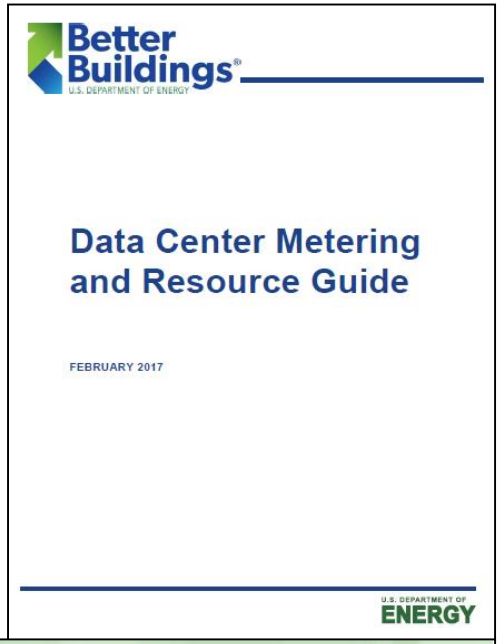
- Move applications and/or hardware to higher-efficiency internal or external data center or to the cloud
- Implement IT and infrastructure power monitoring
- Install Variable-Speed Drives on cooling system fans
- Install rack and/or row-level cooling
- Use air-side economizer
- Implement dedicated room cooling (vs. using central building cooling)

Move to higher-efficiency internal or external data center or to the cloud

- Energy savings typically possible by moving applications or machines to
  - Larger data center
  - Co-location center
  - The cloud
- Better security
- Better redundancy
- Better efficiency
- In evaluating options, consider
  - Mandates
  - Moving cost
  - Total ongoing cost of staying vs. moving

Implement IT and infrastructure power monitoring

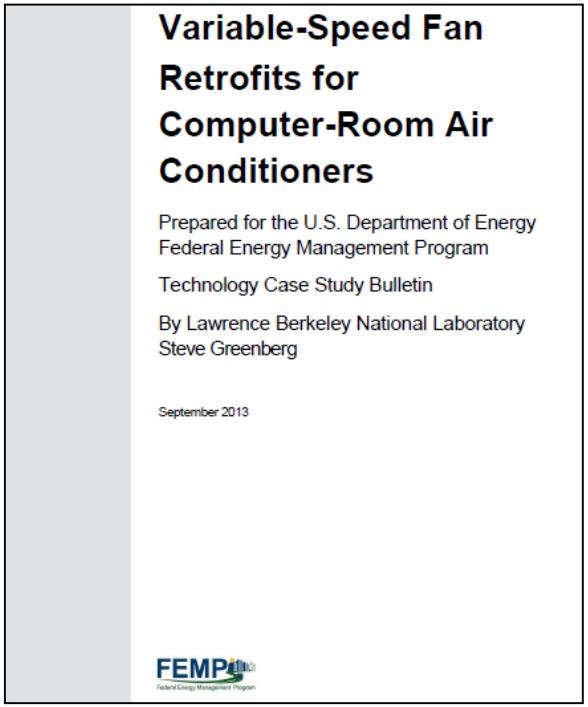
- Doesn't save energy by itself, but it informs the process
- Track performance of power and cooling systems and monitor IT
- Power Usage Effectiveness (PUE) as a metric
  - Ratio of total data center energy to IT energy
  - Measure of infrastructure energy overhead
    - Over 2.0—large opportunity
    - Under 1.5—good
    - Under 1.2--excellent
- Data Center Metering Webinar and Resource Guide
  - Guide: datacenters.lbl.gov/resources/data-center-metering-and-resource-guide
  - Webinar slides: datacenters.lbl.gov/resources/data-center-metering-and-power-usage



Install Variable-Speed Drives on cooling system fans

- CRACs or CRAHs typically have constant-speed fans
- Air flows are typically higher than needed, especially once air management is improved
- 20% air flow reduction results in ~50% savings in fan energy
- 22-32% overall cooling system savings in FEMP case studies:

datacenters.lbl.gov/resources/variable-speed-fan-retrofits-computer-room-air-conditioners



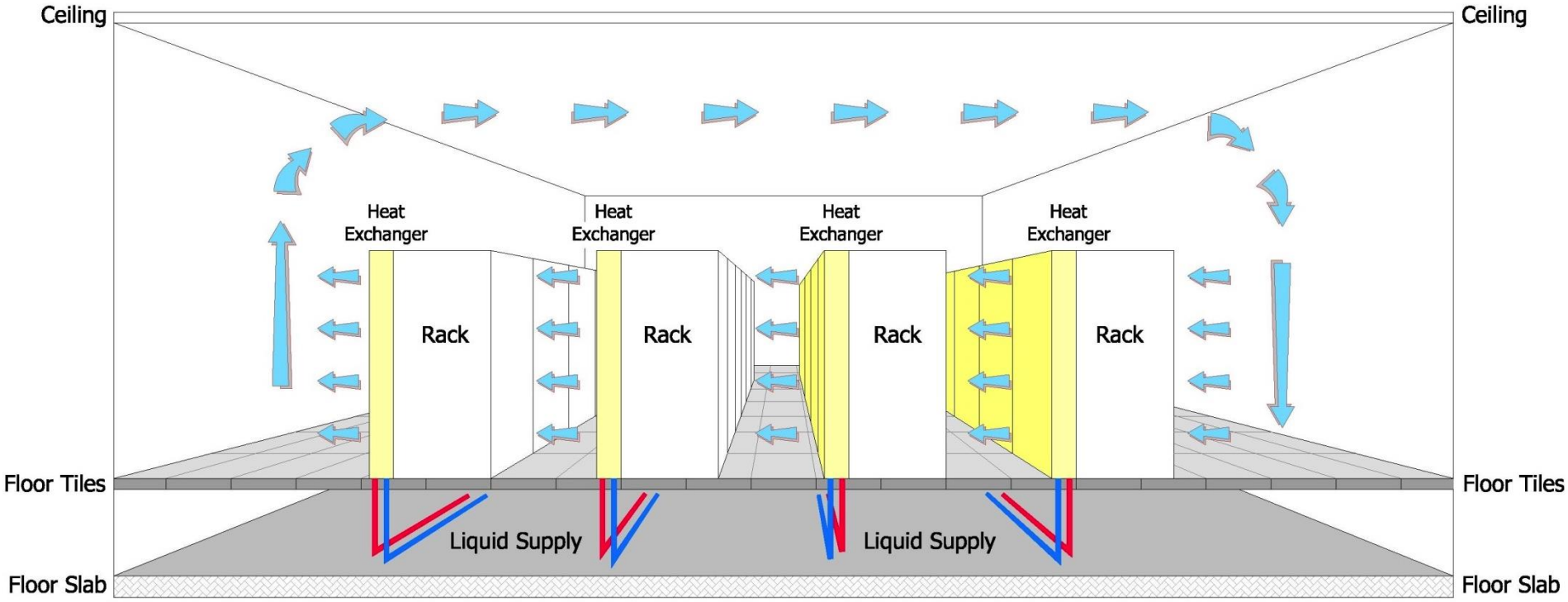
Install rack and/or row-level cooling

- Applicable when racks are being replaced or newly installed
- Moves cooling closer to the heat source (Closer = More Efficient)
- Various types
  - In-row
  - Rear-door (shown)
  - In-rack

Benefits:

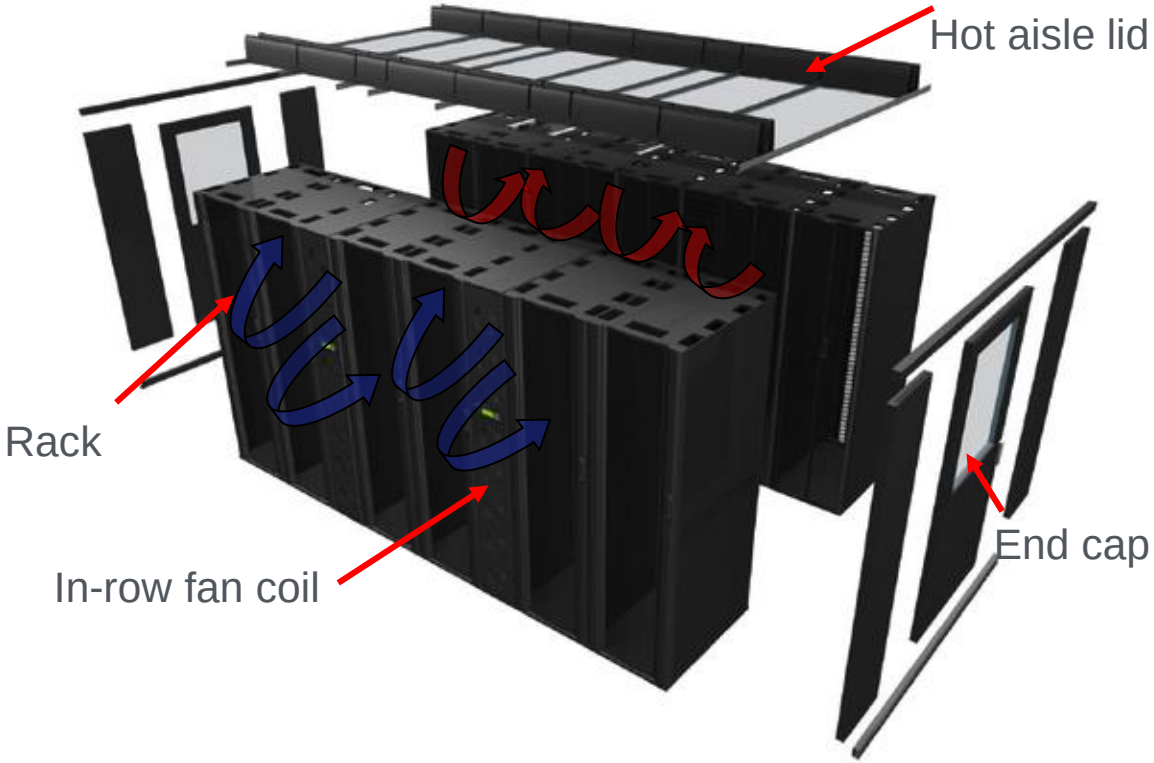
- Closer cooling system is more efficient and so generates less heat that needs to be removed
- Higher chilled water temperature:
  - Makes the cooling plant more efficient
  - Allows “free cooling” for more of the year (water-side economizer)

Rack-Mounted Heat Exchangers (“Rear Doors”)



In-Row Cooling System

With hot aisle containment, the general data center space is neutral (75°F–80°F).



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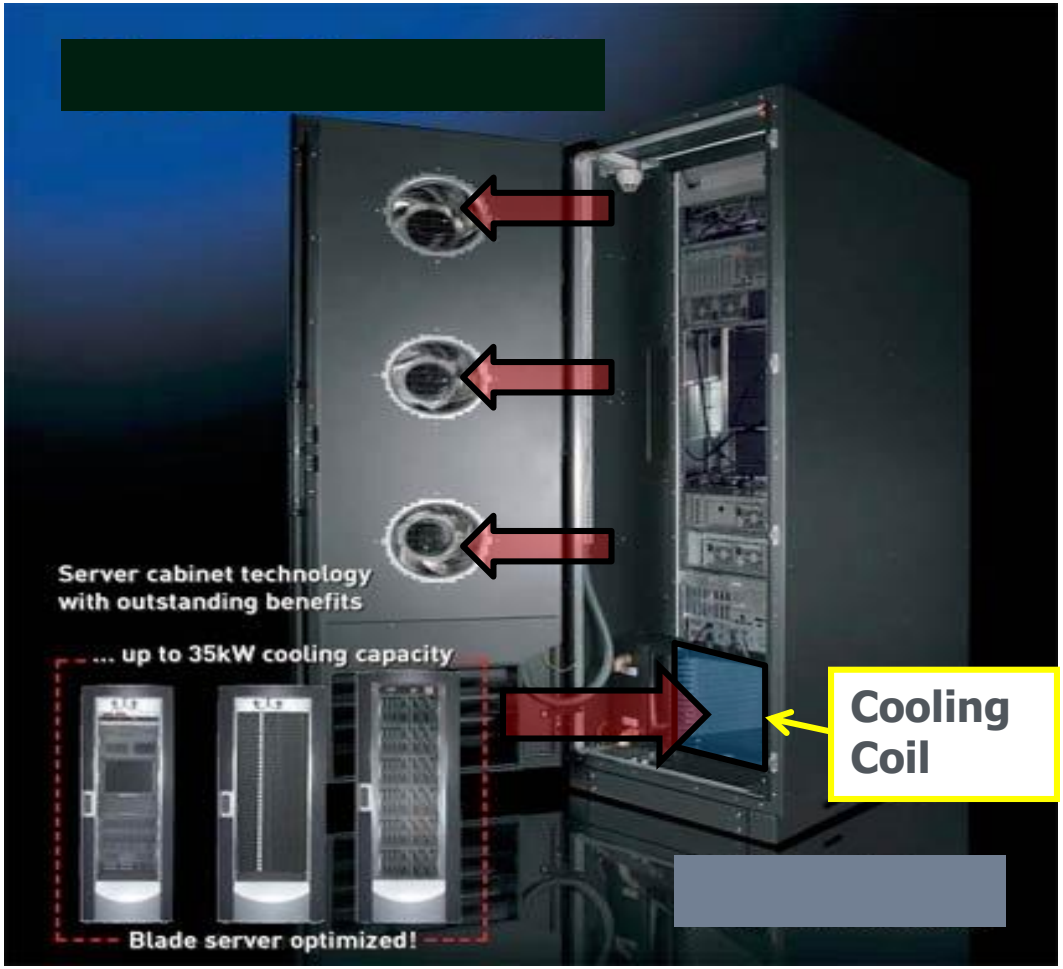
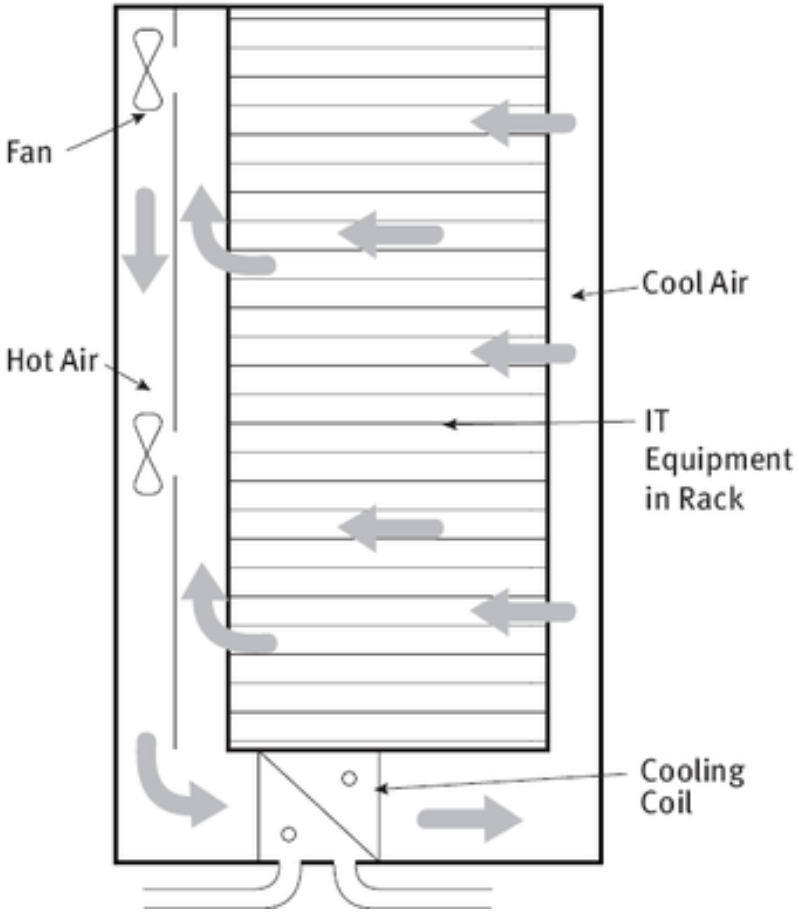
In-Rack Liquid Cooling

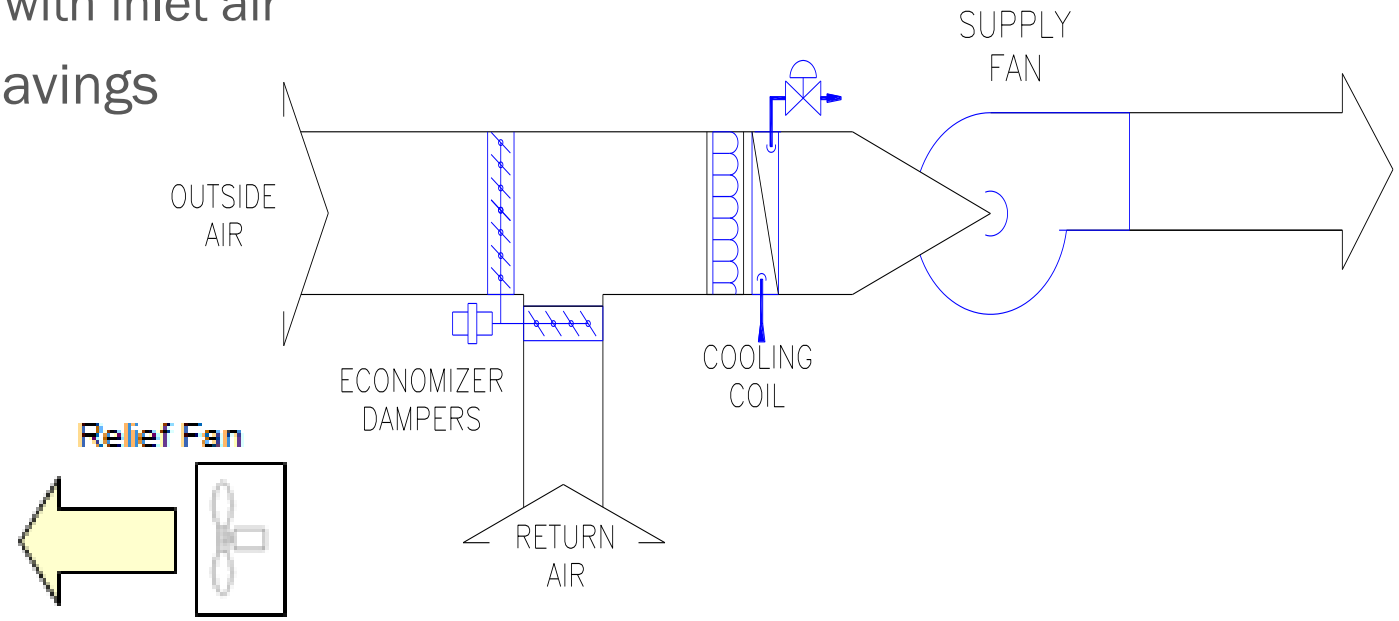
Racks with integral coils and full containment:





Use an air-side economizer

- Uses outside air when conditions are suitable
- Needs outside wall or roof for adequate access to large airflow
- Can be
  - air-handling unit
  - CRAC or CRAH with outside air capability
  - Exhaust fan with inlet air
- Large energy savings from reduced operation of cooling compressor



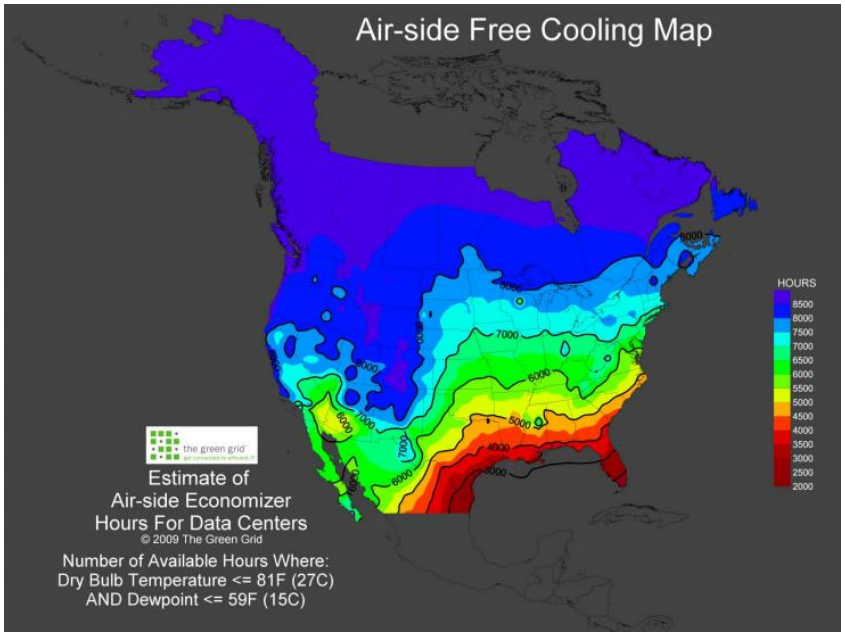
Outside Air (Air-Side) Economizers

Advantages

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

Potential Issues

- Space (retrofit projects difficult)
- Outside dust
  - Not a concern with MERV 13 filters
- Outside gaseous contaminants
  - Not widespread
  - Impacts normally cooled data centers as well
- Shutdown or bypass if smoke or other contaminant is outside data center



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

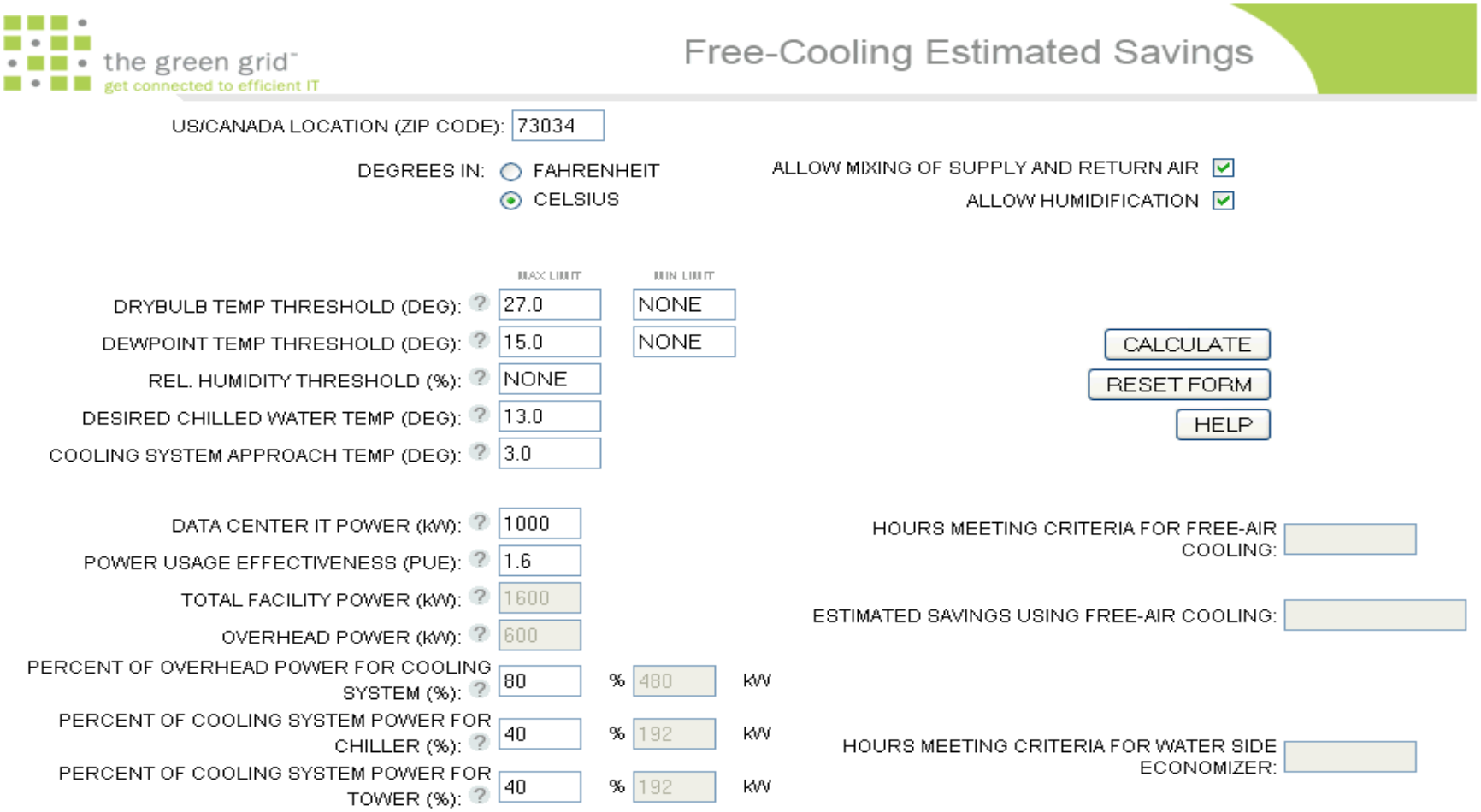
Use a Water-Side Economizer

- Easier retrofit
- Added reliability (backup in case of chiller failure)
- No contamination issues
- Put in series with chiller (“integrated”)
- Uses tower or dry cooler

No or minimum compressor cooling

Cooling tower and HX = Water-side Economizer

Economizers: The Green Grid Tool



Implement dedicated room cooling (vs. using central building cooling)

- Dedicated unit allows main building system and plant to operate on normally occupied schedule instead of continuously
  - Allows for cooling operations independent from rest of the building
  - A small, imbedded data center can cause a central plant to operate when the rest of the building doesn't require it

What to do:

- Use high-efficiency unit - high SEER (Seasonal Energy Efficiency Ratio)
- Specify outside-air economizer
- Control based on IT inlet temperature

Sources of Training for Facilities and IT Staff

- Utility companies
- ASHRAE: www.ashrae.org
- Federal Energy Management Program (FEMP): http://eere.energy.gov/femp/training
- Center of Expertise for Energy Efficiency in Data Centers
- Data Center Energy Practitioner
  - Required by the Data Center Optimization Initiative
  - datacenters.lbl.gov/dcep

Data Center Energy Practitioner (DCEP) Program

U.S. DOE certificate process for energy practitioners qualified to assess energy consumption and energy efficiency opportunities in data centers.

Key objective:

- Raise the standard of energy assessors
- Greater repeatability/credibility of recommendations

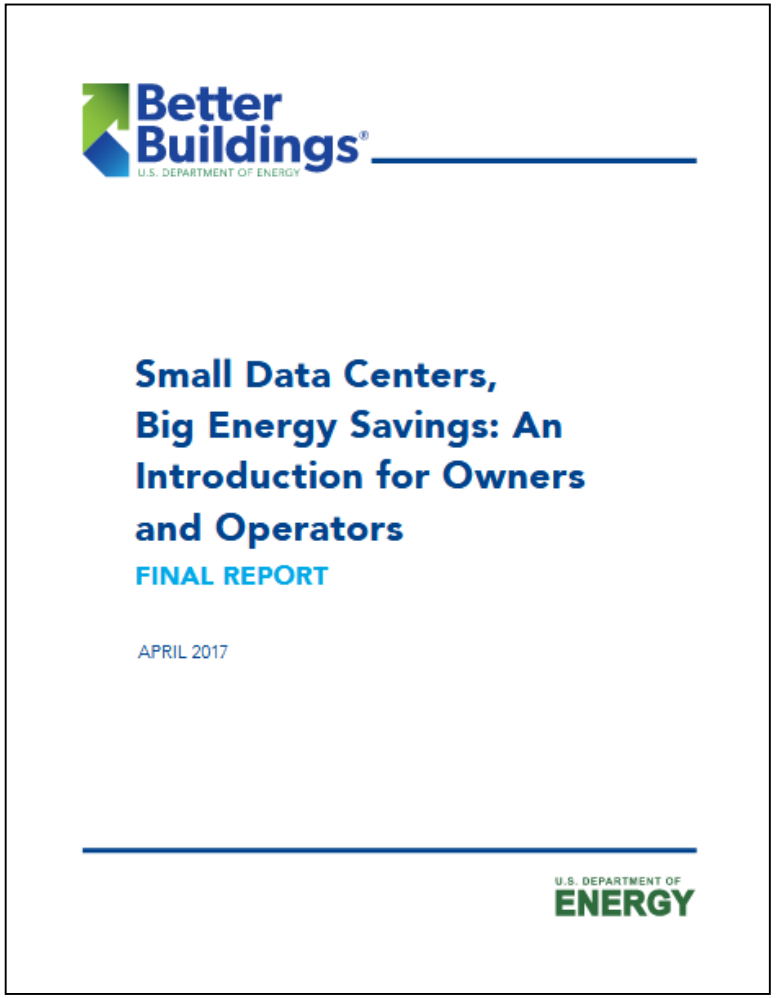
Target groups include:

- Data center personnel (in-house experts)
- Consulting professionals (for-fee consultants)

Resources

- Small Data Center Guide:

betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Better Buildings Data Center Accelerator - Small Data Center Energy Savings Guide.pdf



More Resources

DOE Better Buildings

- Tool suite & metrics for base-lining
- Training
- Showcase case studies
- Recognition of high energy savers

Federal Energy Management Program

- Workshops
- Federal case studies
- Federal policy guidance
- Information exchange & outreach
- Qualified specialists
- Technical assistance

EPA

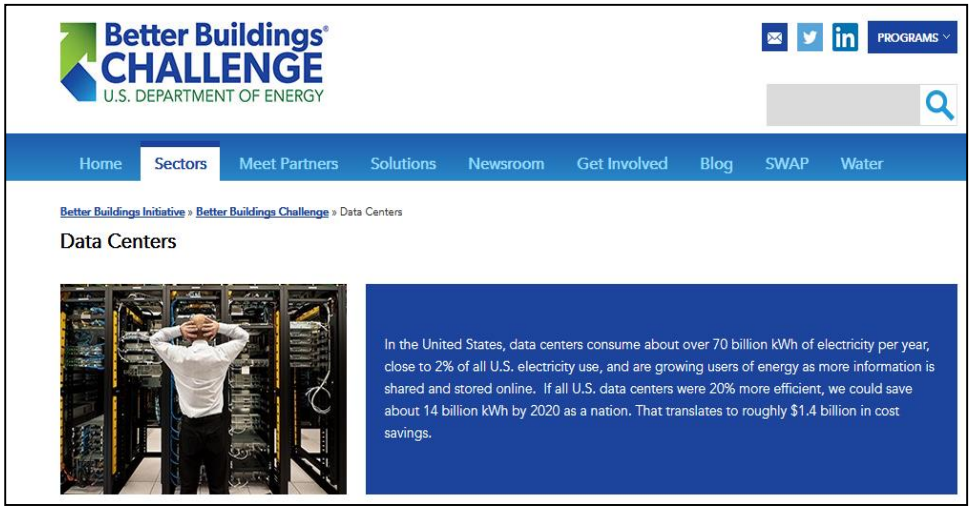
- Metrics
- Server, UPS, network equipment performance rating & ENERGY STAR label
- Data center benchmarking

Industry

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

More Resources

Better Buildings Solutions Center:
betterbuildingssolutioncenter.energy.gov/challenge/sector/data-centers



Center of Expertise for Energy Efficiency in Data Centers:
datacenters.lbl.gov

Resources: Center of Expertise (CoE)

https://datacenters.lbl.gov/

Data Center Resources

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

Resources, con't.

- DOE Air Management Tools
  datacenters.lbl.gov/tools/5-air-management-tools
- Humidity Control in Data Centers
  datacenters.lbl.gov/resources/Humidity-Control-Data-Centers
- Data Center Metering and Resource Guide
  datacenters.lbl.gov/resources/data-center-metering-and-resource-guide
- Variable-Speed Fan Retrofits for Computer-Room Air Conditioners
  - Case study of 3 small data centers
  datacenters.lbl.gov/resources/variable-speed-fan-retrofits-computer-room-air-conditioners
- Data Center Optimization Initiative (OMB): https://datacenters.cio.gov/
- ENERGY STAR Equipment: energystar.gov/products/office_equipment/

Summary

- Why small data centers are important

- Simplest Measures
  - Turn off unused servers
  - Improve server power management
  - Improve air management
  - Increase temperature setpoints toward the high end of the range set by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE)
  - Turn off active humidity control
  - Minimize requirements for Uninterruptible Power Supplies (UPS)

Summary, con't

- Still simple, a little more work
  - Refresh the oldest IT equipment with new high-efficiency equipment
  - Consolidate and virtualize applications
- Higher-level investment, but very cost-effective
  - Move applications and/or hardware to higher-efficiency internal or external data center or to the cloud
  - Implement IT and infrastructure power monitoring
  - Install Variable-Speed Drives on cooling system fans
  - Install rack and/or row-level cooling
  - Use air-side or water-side economizer
  - Implement dedicated room cooling (vs. using central building cooling)
- Training for IT and Facility Staff
- Resources

Energy Exchange Pre-Conference Workshop CEU Guidance

Register with the Whole Building Design Guide (if new):
www.wbdg.org/continuing-education/energy-exchange

Sign IN and OUT when ENTERING and LEAVING the training session.

Stay for the entire session; attendance of the entire session will be confirmed for CEU eligibility. Do not take the quiz if you did not attend the entire session.

On the WBDG website, pass a session quiz (with a minimum score of 80%) and complete a session evaluation ***no later than October 31, 2018***. Available by Tuesday, August 21st.

For **How to Save Money in Your Small Data Center,** complete your quiz at the following link:

http://www.wbdg.org/continuing-education/femp-courses/fempws08202018o

FEMP
Federal Energy Management Program

Questions

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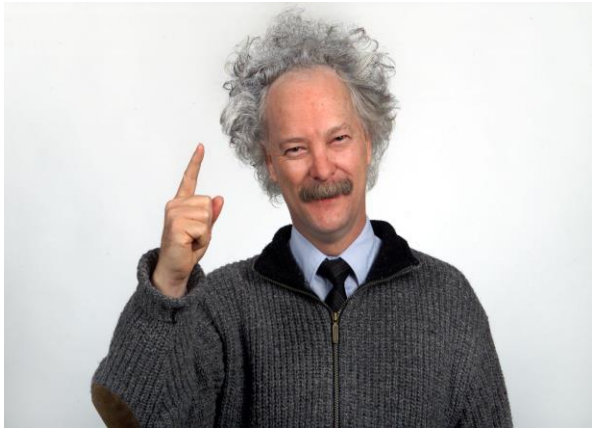

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