Better Buildings Webinar Series

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Better Buildings®
U.S. DEPARTMENT OF ENERGY

Solutions for Small- to Medium-Sized Data Centers – Air Management

June 4, 2019

3:00 – 4:00 PM EST

U.S. DEPARTMENT OF ENERGY

Today's Presenters

Name		Organization
Steve Greenberg		Lawrence Berkeley National Lab
John Sasser		Sabey Data Centers

Steve Greenberg

Lawrence Berkeley National Lab

U.S. DEPARTMENT OF ENERGY

The Early Days at LBNL

It was cold, but hot spots were everywhere:

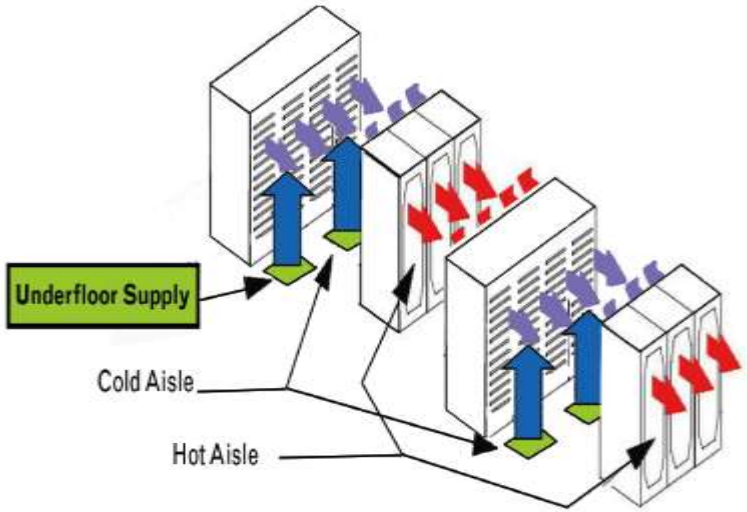
Fans were used to redirect air

High-flow tiles reduced air pressure

Air Management

- Problems:
  - By-pass air
  - Re-circulation air
- Solution:
  - Air Management

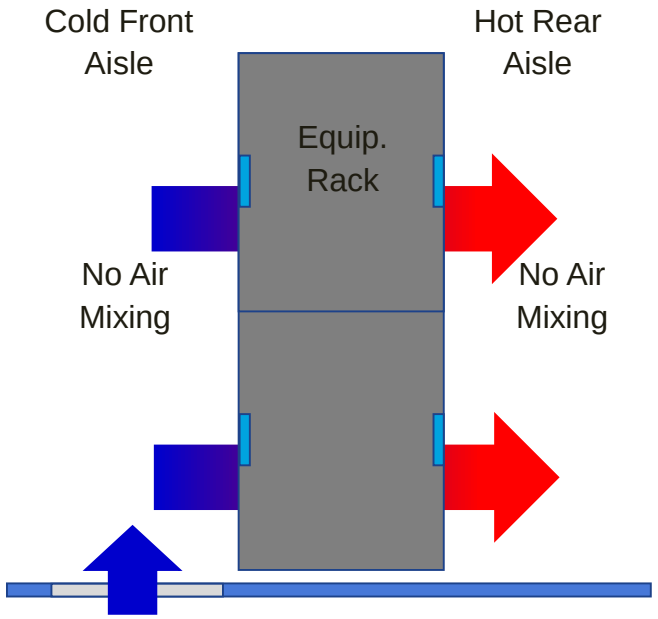
- Use hot and cold aisles
- Improve isolation of hot and cold aisles
  - Reduce fan energy
  - Improve air-conditioning efficiency
  - Increase cooling capacity



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

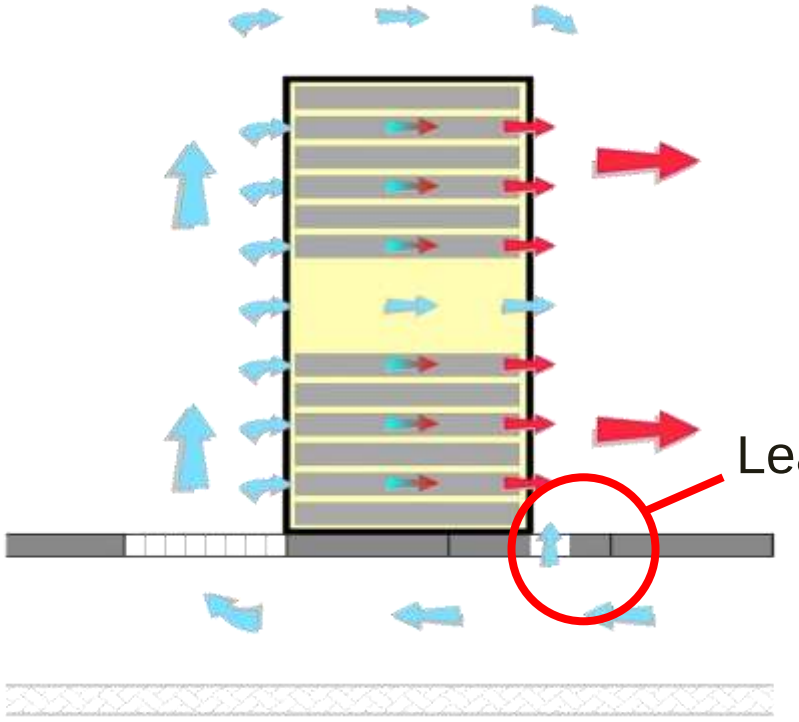
Separating Cold from Hot Airflow

- Supply cold air as close to the rack inlet as possible
- Reduce mixing with ambient air and hot rack exhaust
- Air moves from the front cold aisle to the rear hot aisle



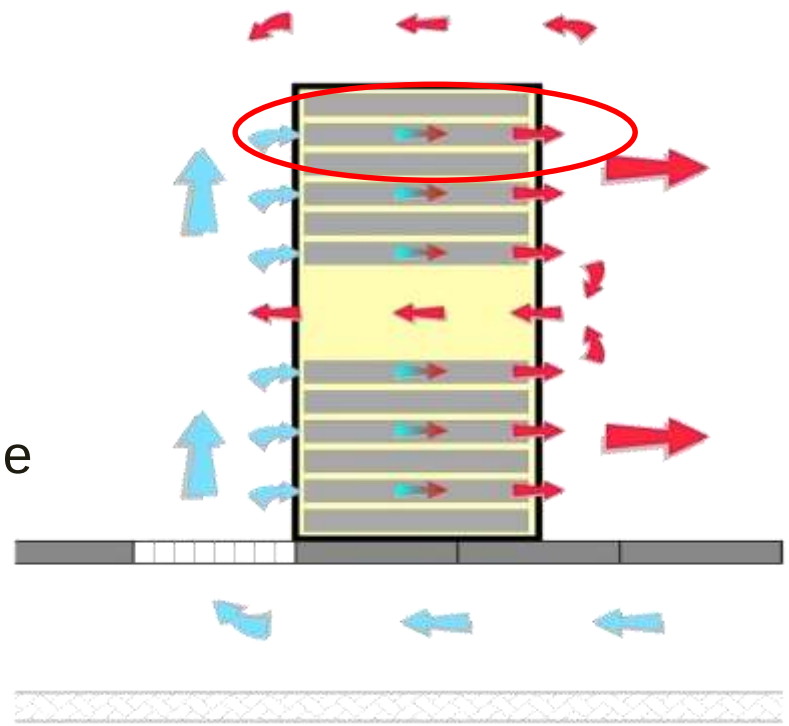
Reduce By-Pass and Recirculation Air

Bypass Air / Short-Circuiting



Wastes fan energy as well as cooling energy and capacity

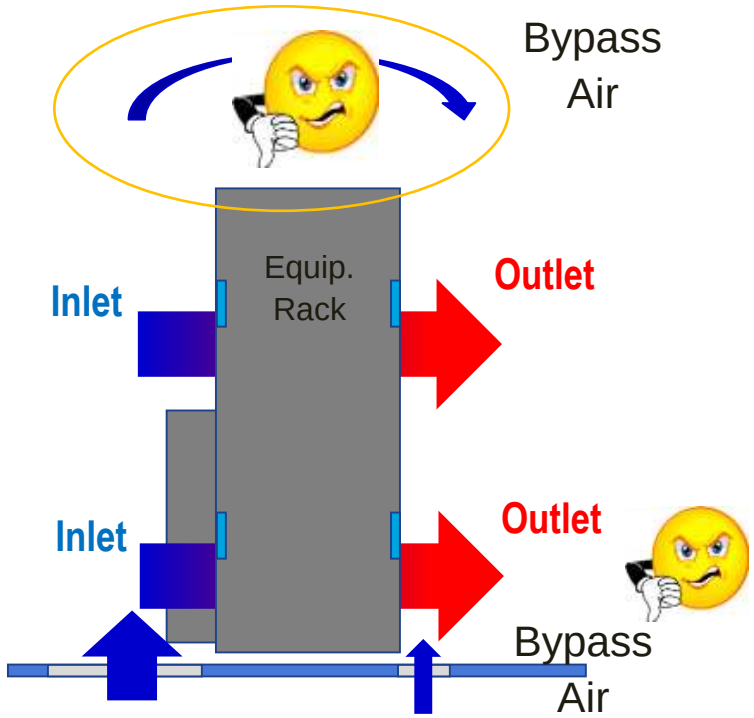
Recirculation



Increases inlet temperature to servers

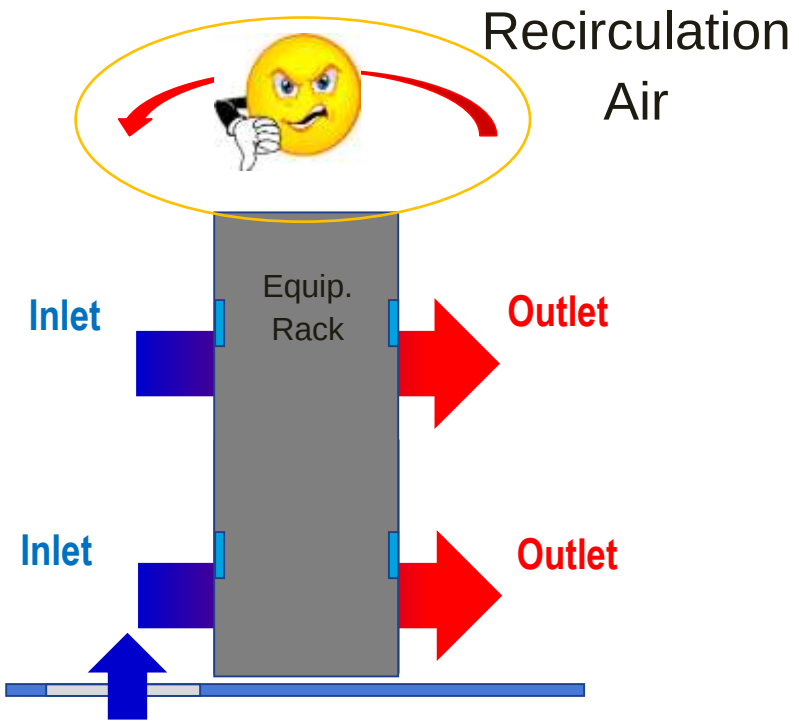
Bypass Air – Common Causes

- Too much supply airflow
- Misplaced perforated tiles
- Leaky cable penetrations
- Too-high tile exit velocity



Recirculation Air – Common Causes

- Too little supply airflow
- Lack of blanking panels
- Gaps between racks
- Short equipment rows



Maintaining Raised-Floor Seals

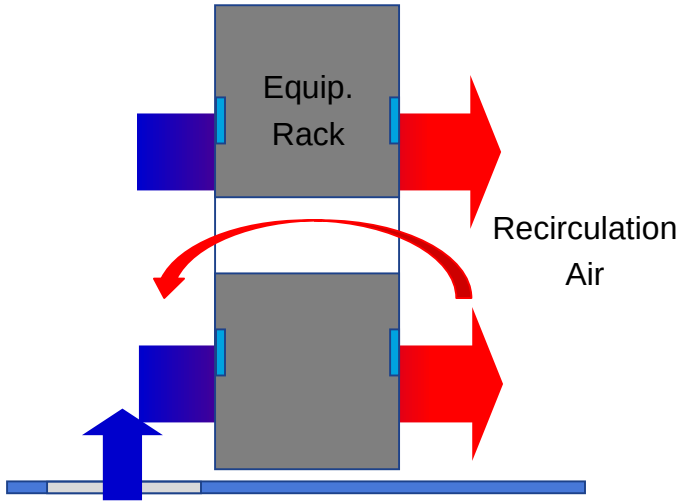
Maintain seals of all potential leaks in the raised floor plenum

Unsealed cable penetration (inside rack)

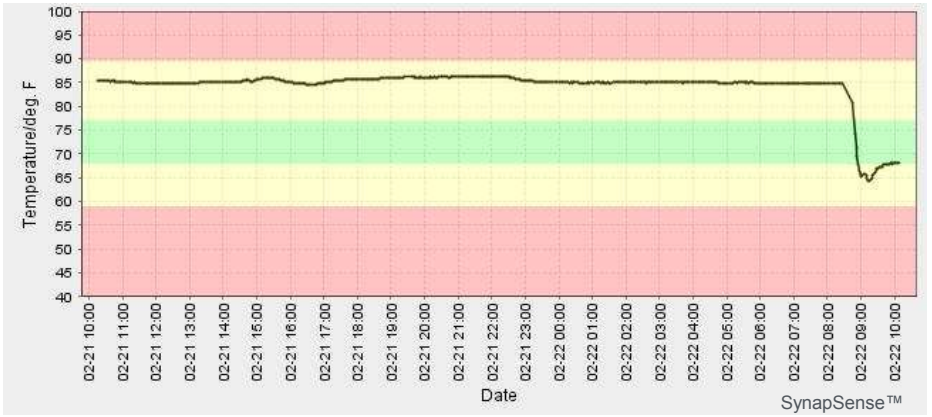
Sealed cable penetration

Managing Blanking Panels

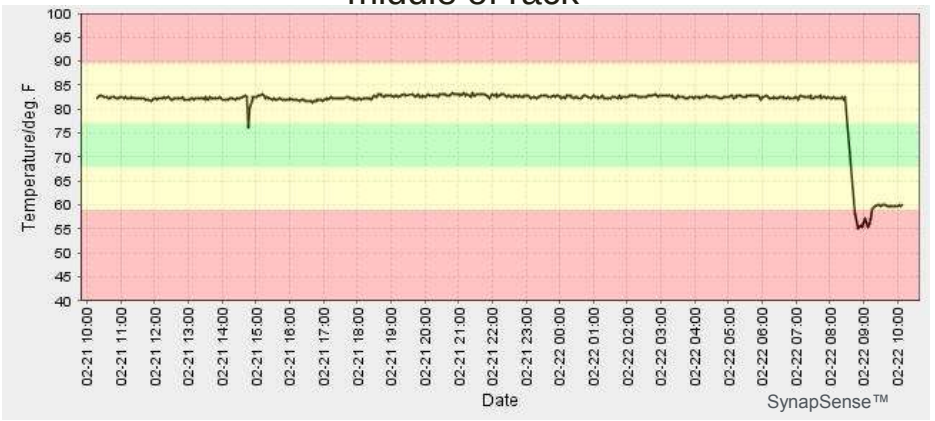
- Any opening will degrade the separation of hot and cold air
- Maintain blanking panels
  - One 12" blanking panel reduced temperature ~20°F



top of rack

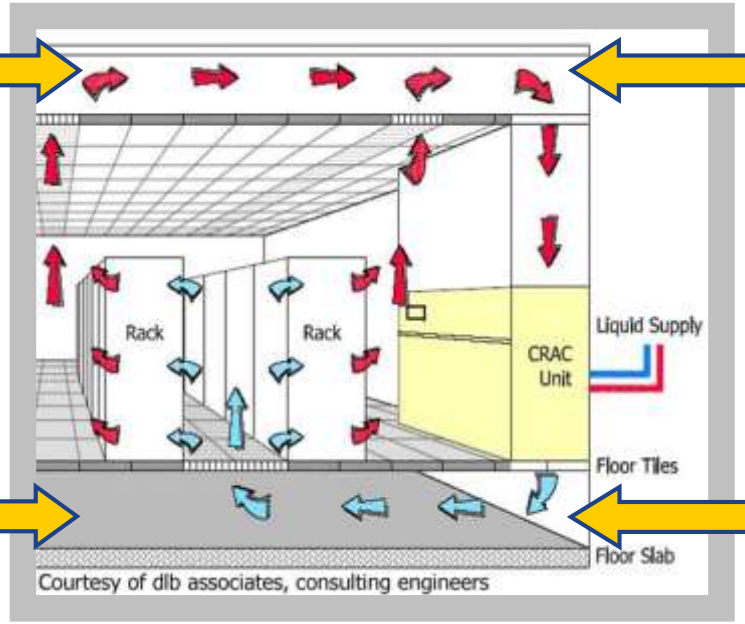


middle of rack



Reduce Airflow Restrictions & Congestion

Congested Floor & Ceiling Cavities

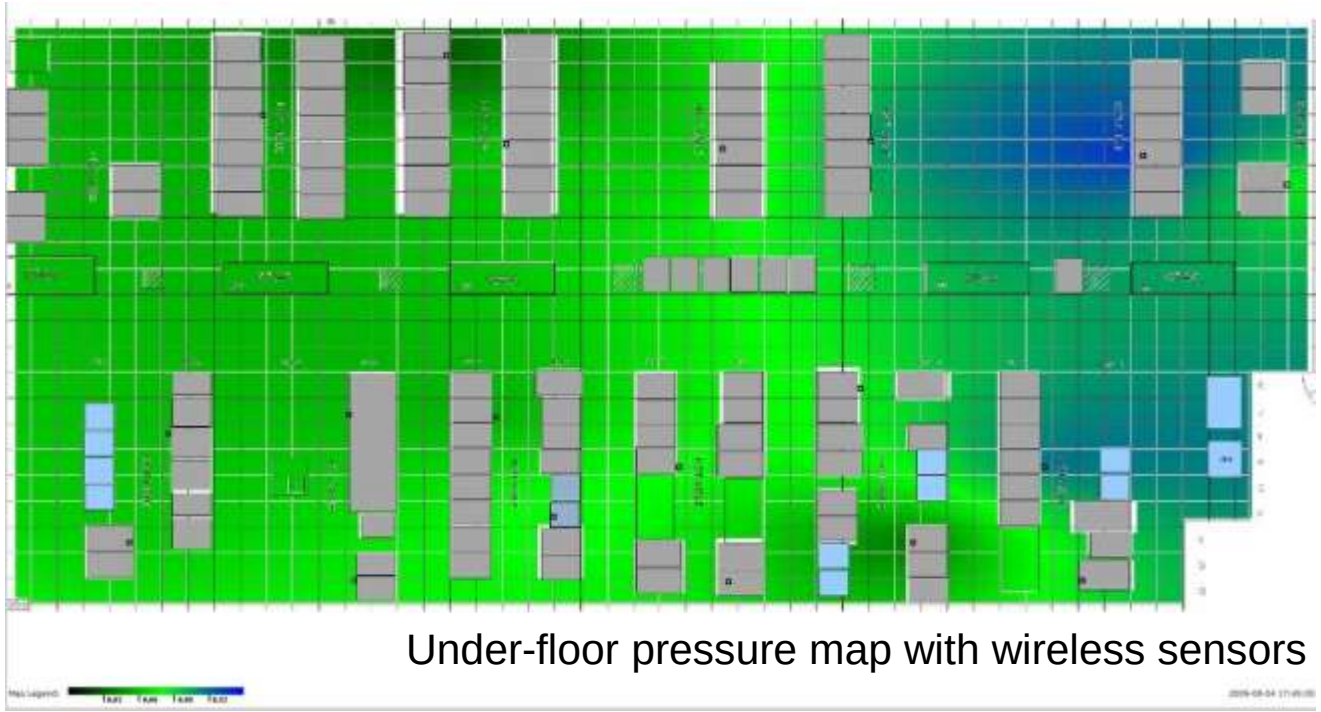


Consider the Impact that Congestion Has on the Airflow Patterns

Empty Floor & Ceiling Cavities

Resolve Airflow Balancing

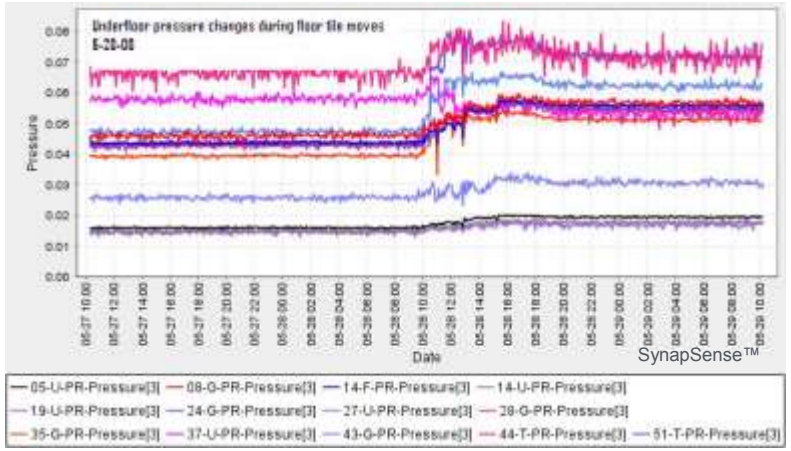
- Balancing is required to optimize airflow
- Rebalance with new IT or HVAC equipment
- Place perforated floor tiles *only* in cold aisles



Under-floor pressure map with wireless sensors

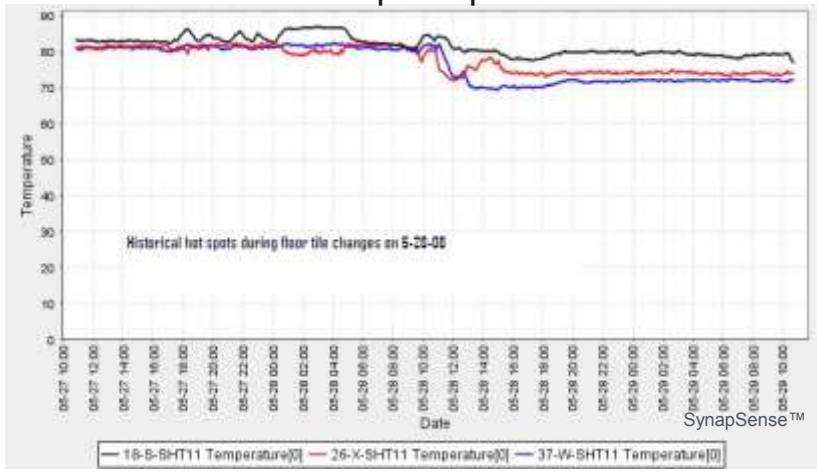
Results: Tune Floor Tiles

under-floor pressures

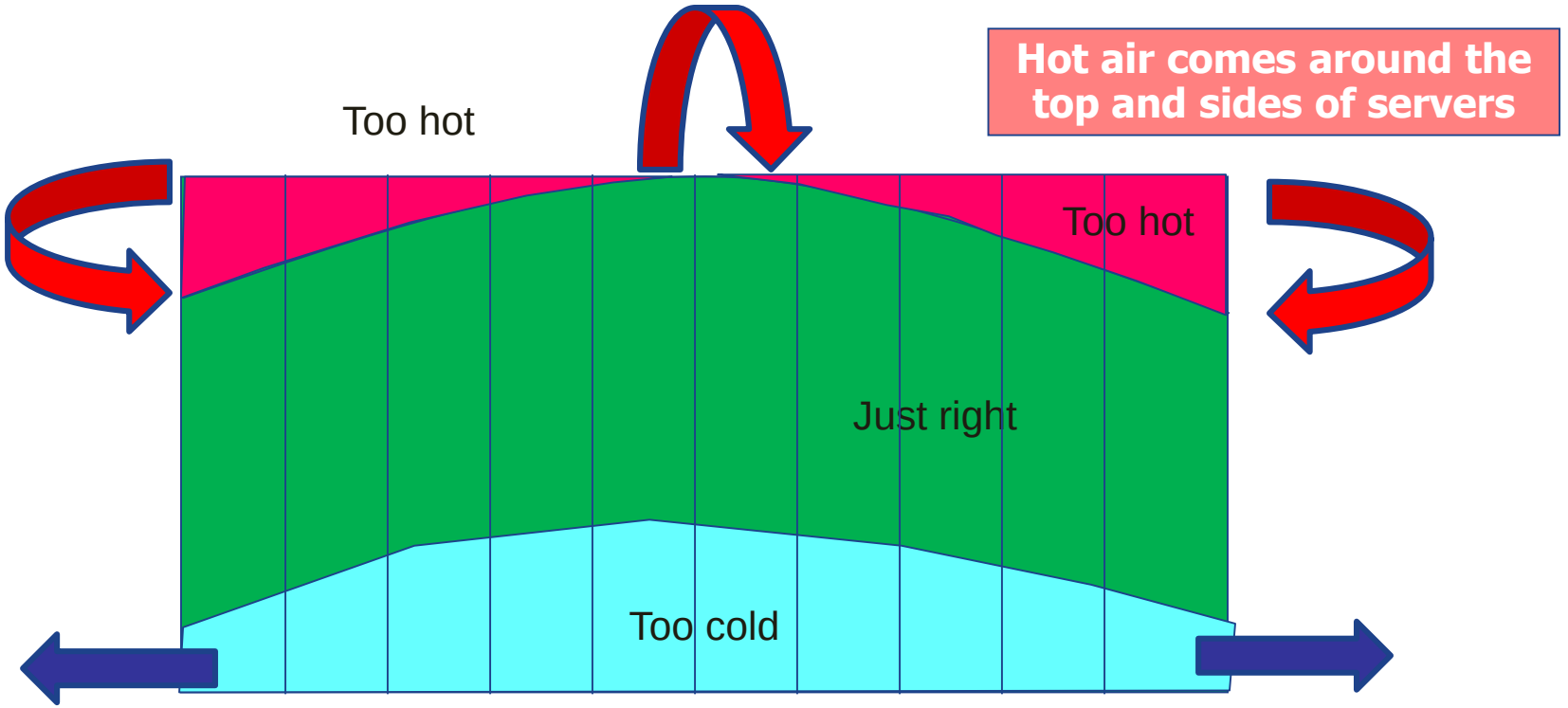


- Too many permeable floor tiles
- If airflow is optimized
  - under-floor pressure ↑
  - rack-top temperatures ↓
  - data center capacity increases
- Measurement and visualization assisted the tuning process

rack-top temperatures

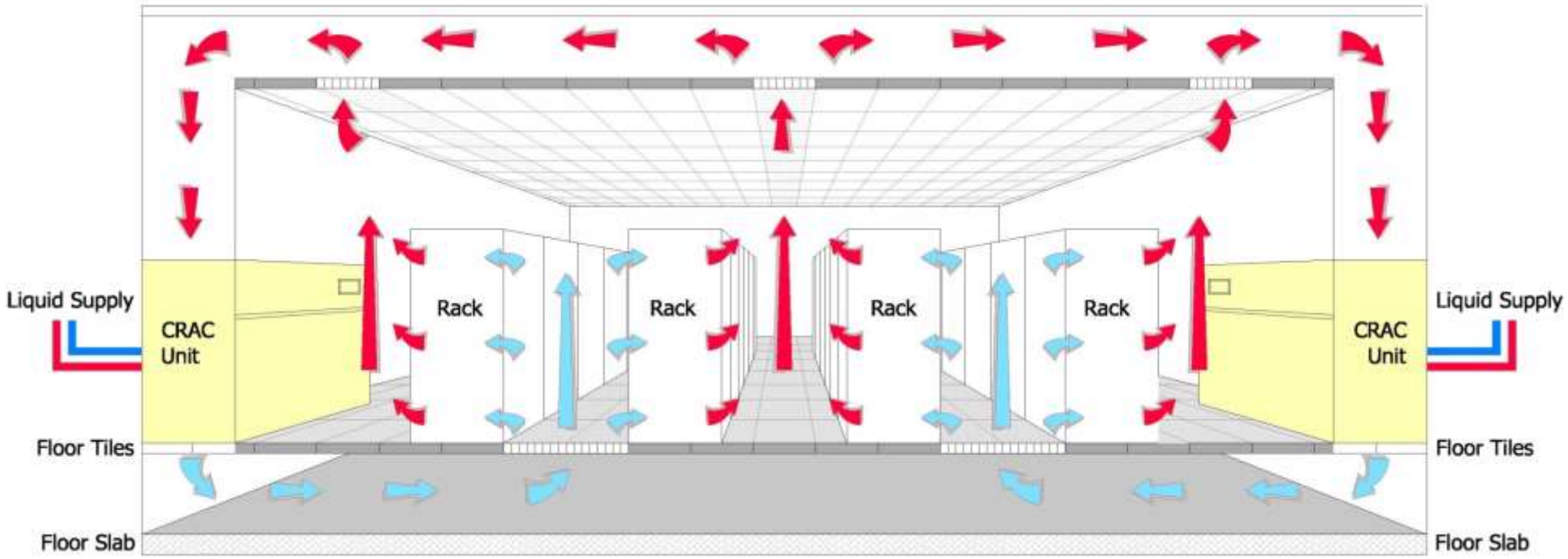


Typical Temperature Profile with Under-floor Supply



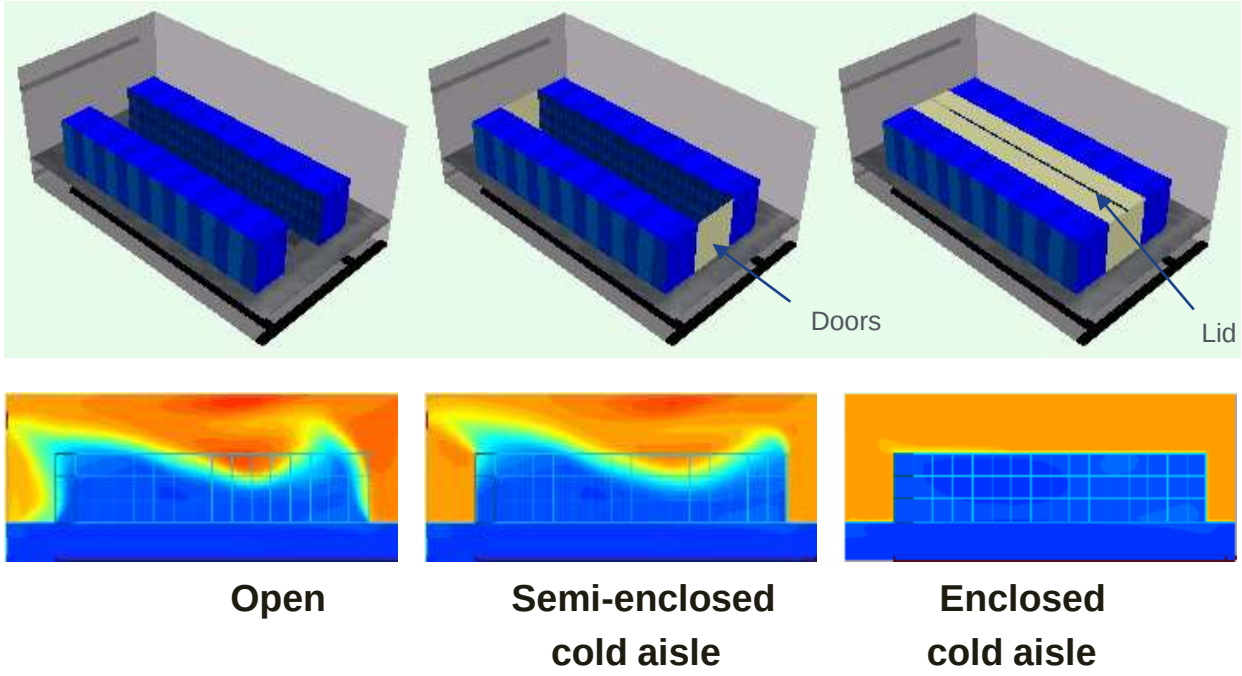
There are numerous references in ASHRAE.
See for example V. Sorell et al; “Comparison of Overhead and Underfloor Air Delivery Systems in a Data Center Environment Using CFD Modeling”; ASHRAE Symposium Paper DE-05-11-5; 2005.

Next step: Air Distribution Return-Air Plenum



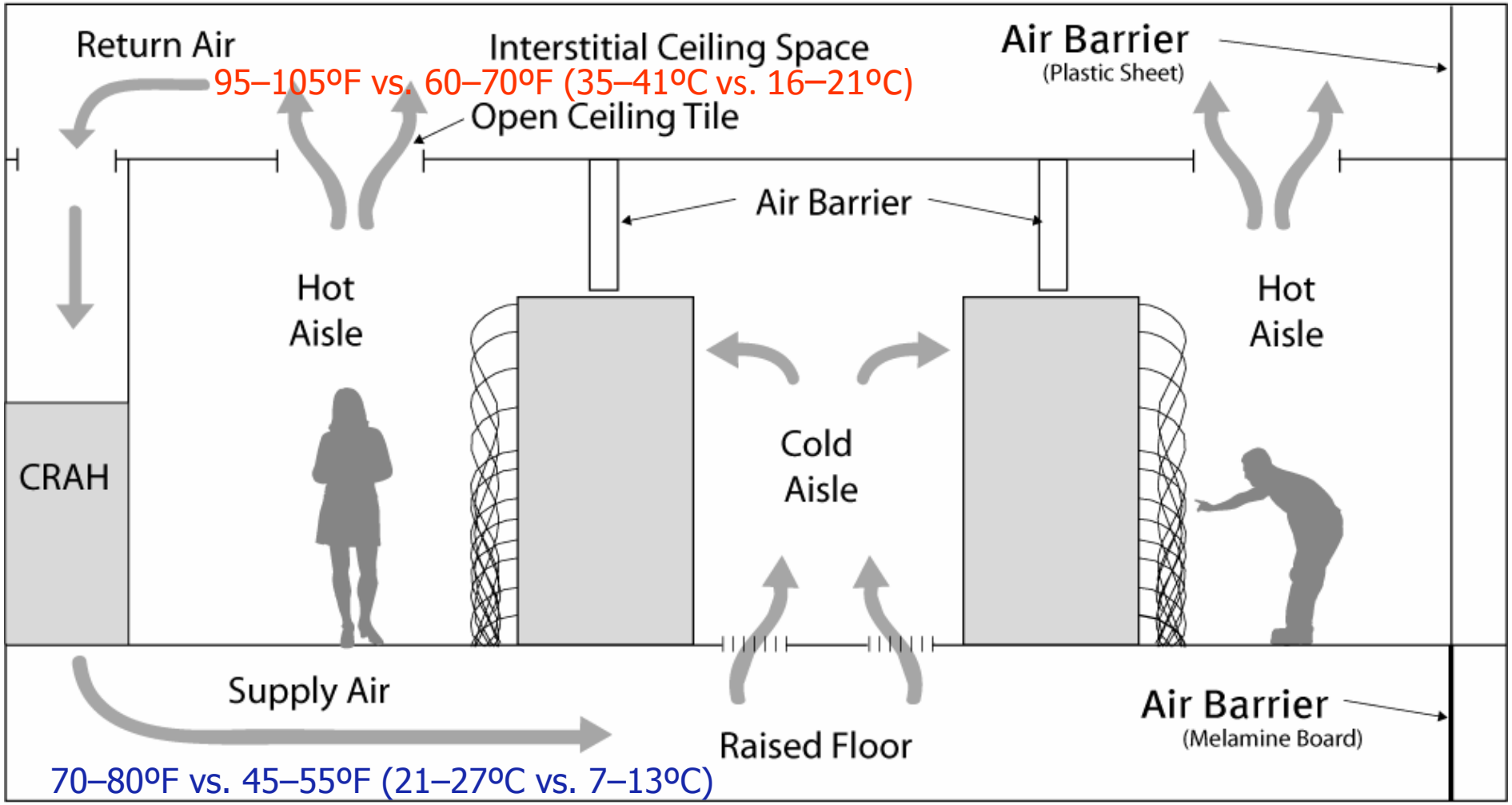
Enhanced Isolation Options

- Physical barriers enhance separate hot and cold airflow
- Barrier placement must comply with fire codes
- Curtains, doors, or lids have been used successfully

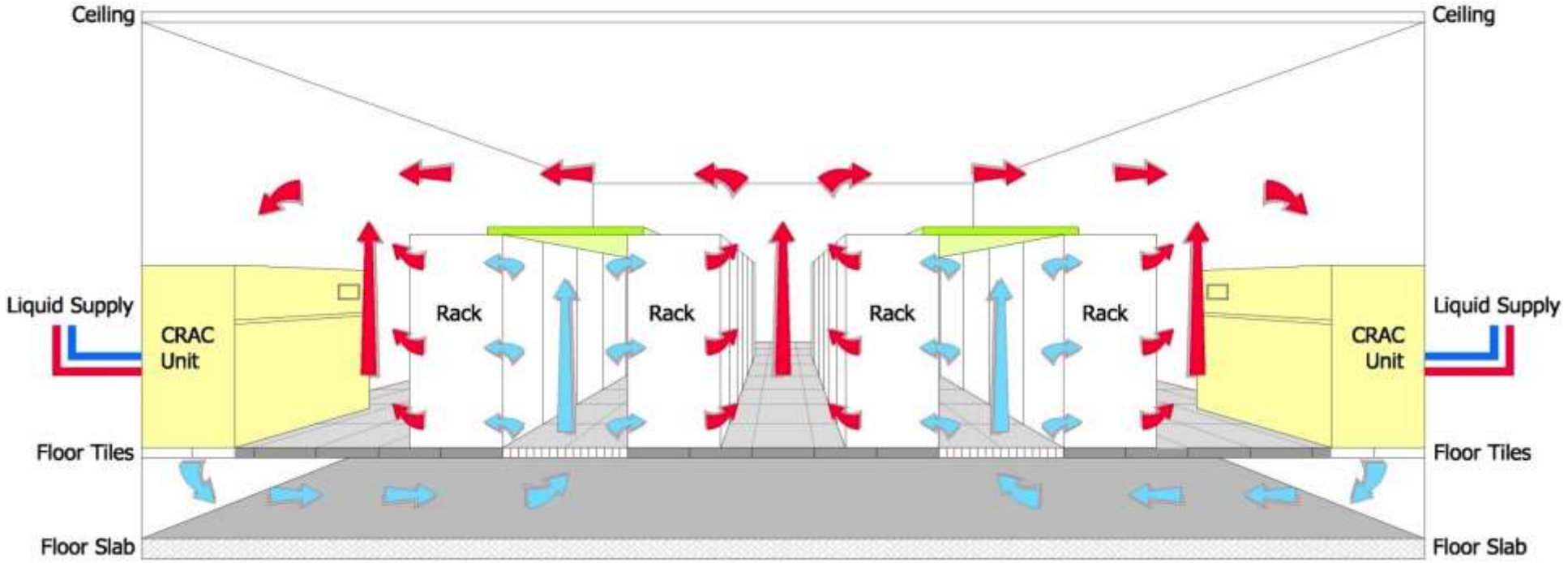


Adding Air Curtains for Hot/Cold Isolation

Air Management: Separate Cold and Hot Air



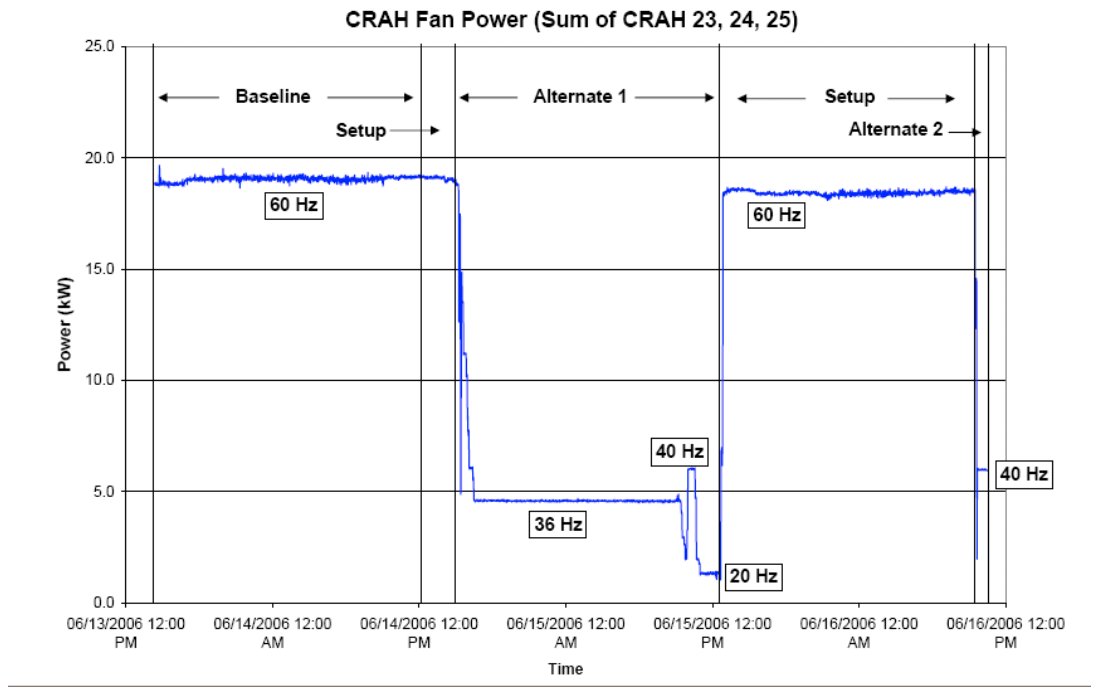
Cold Aisle Airflow Containment Example



LBNL's Cold Aisle Containment study achieved fan energy savings of ~75%

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

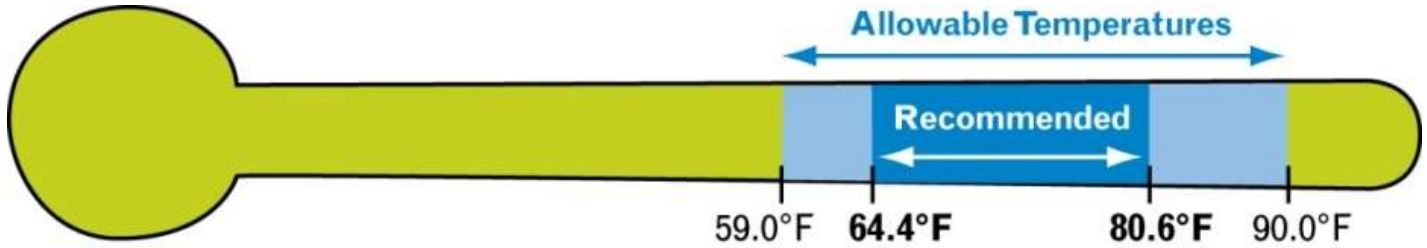


Without Enclosure With Enclosure Without Enclosure

ASHRAE Thermal Guidelines

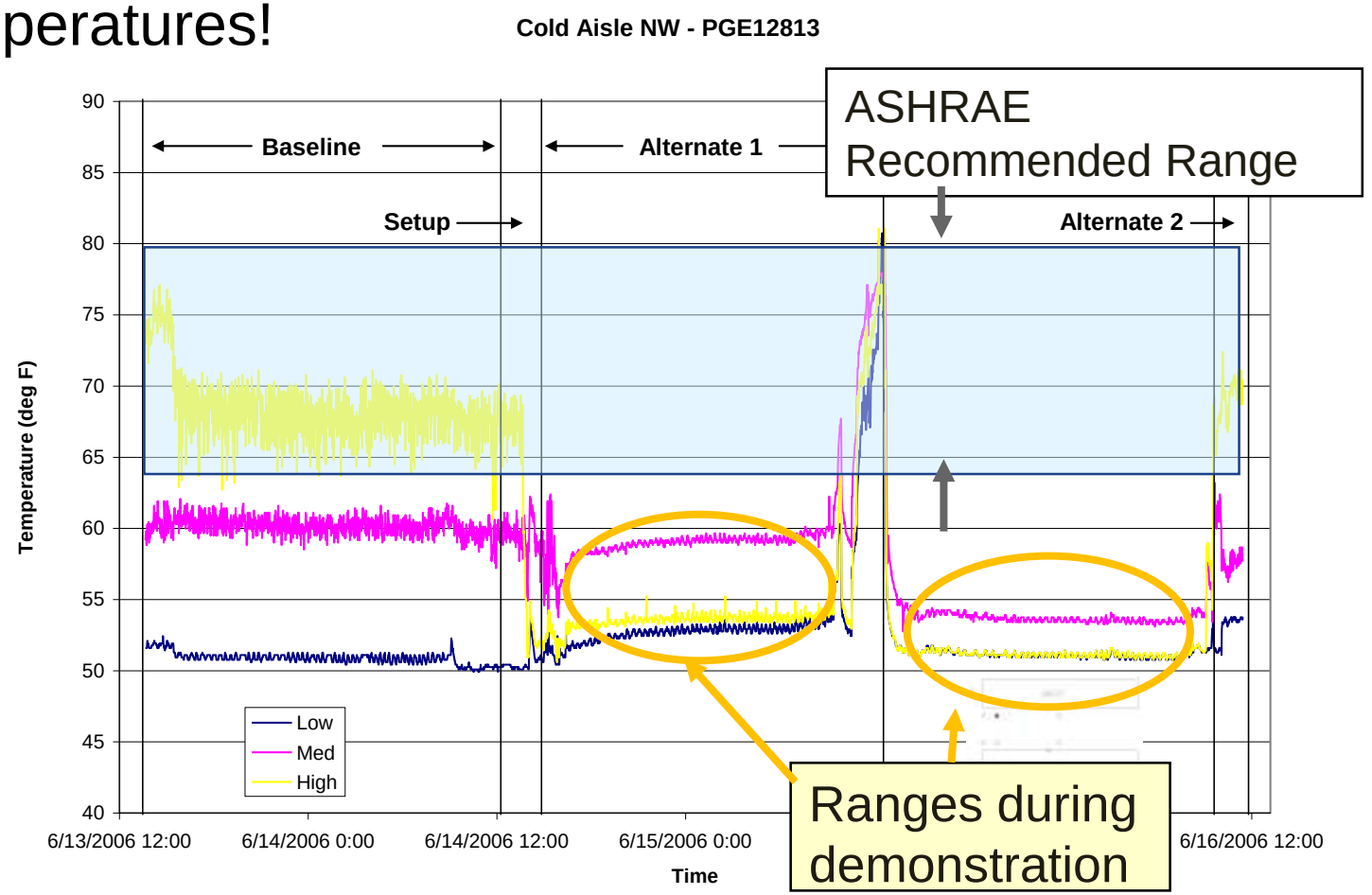
- Default recommended range = 64.4 - 80.6F
- Provides guidance for operating above the default upper limit

- Default allowable range = 59.0 – 89.6F (Class A1)
- Six classes with allowable ranges up to 113.0F



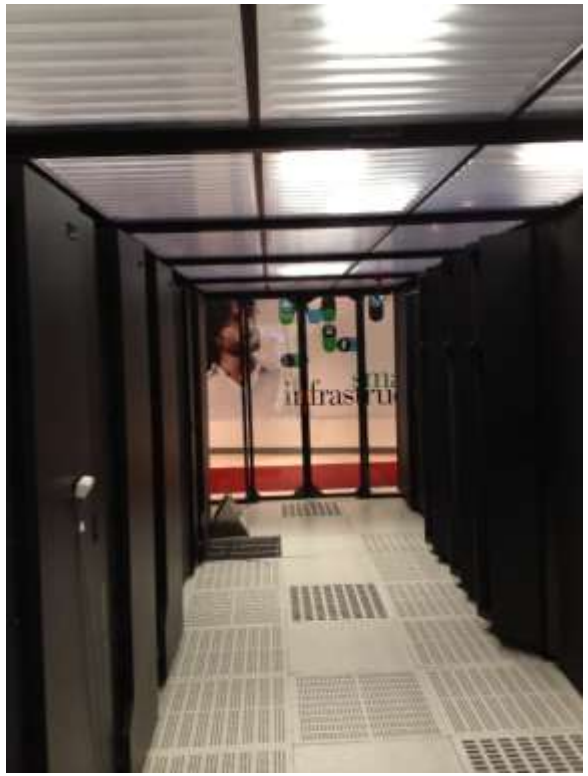
LBNL Air Management Demonstration

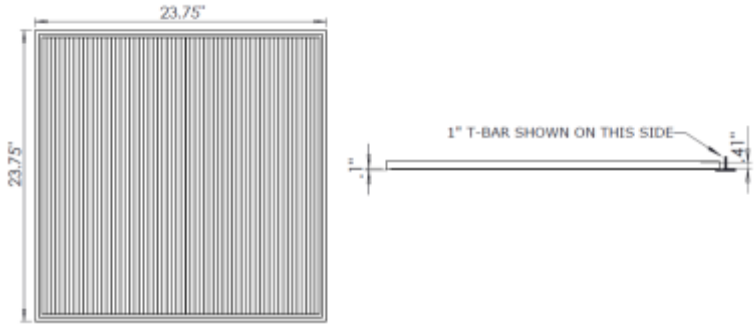
Better airflow management permits warmer supply temperatures!



Hot and Cold Aisle Containment

Subzero Cold Aisle Containment





APC Hot Aisle Containment
(with in-row cooling)

Ceilume Heat Shrink Tiles

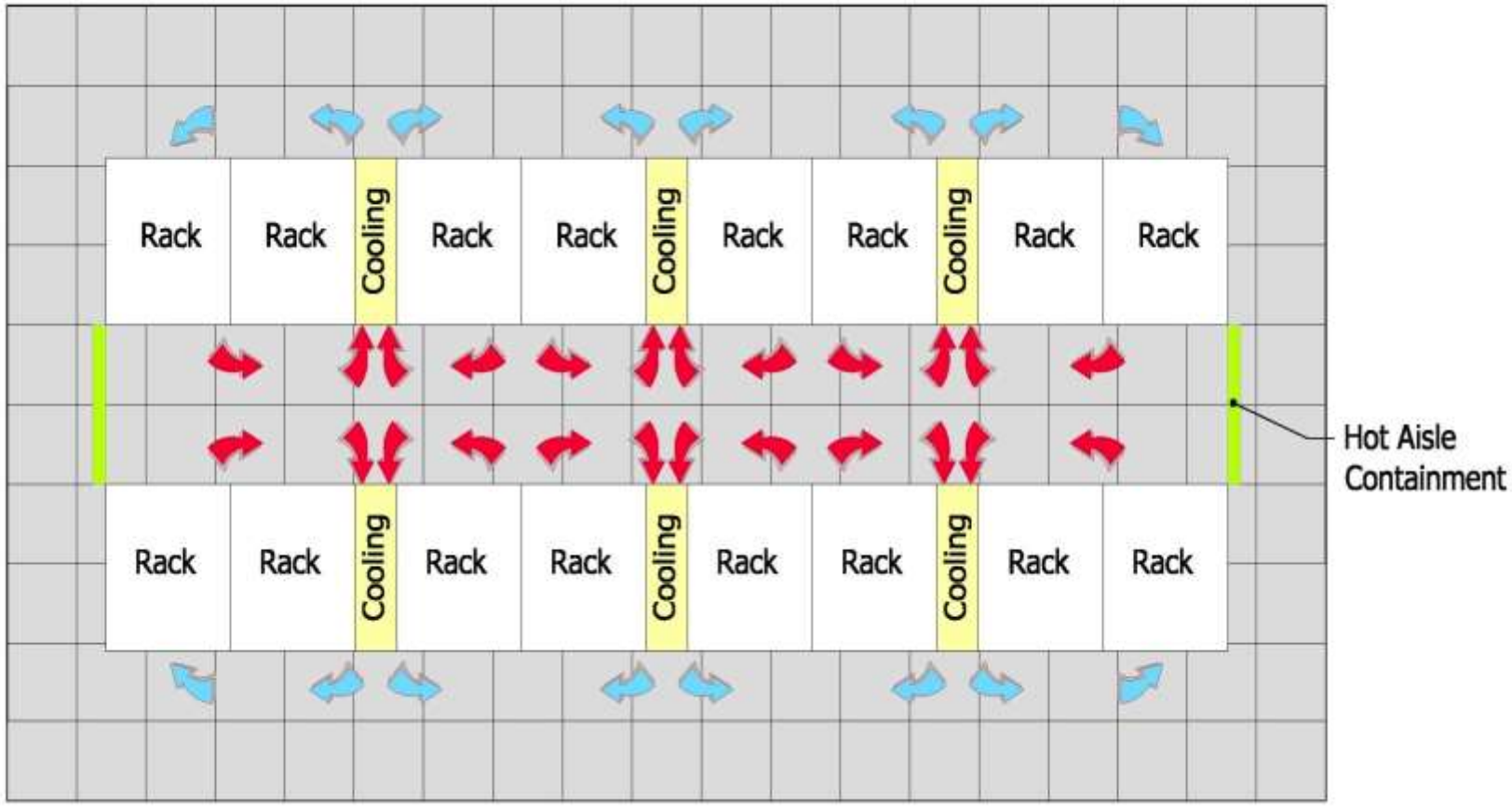
Isolating Hot and Cold Aisles Summary

- Energy intensive IT equipment needs good isolation of “cold” intake and “hot” exhaust
- Supply airflow can be reduced if no bypass occurs (assuming VFD fans)
- Supply temperature can be raised if air is delivered without mixing
- CRACs, chillers and economizers are more efficient with warmer return air temperatures
- Cooling and raised-floor capacity increase with air management

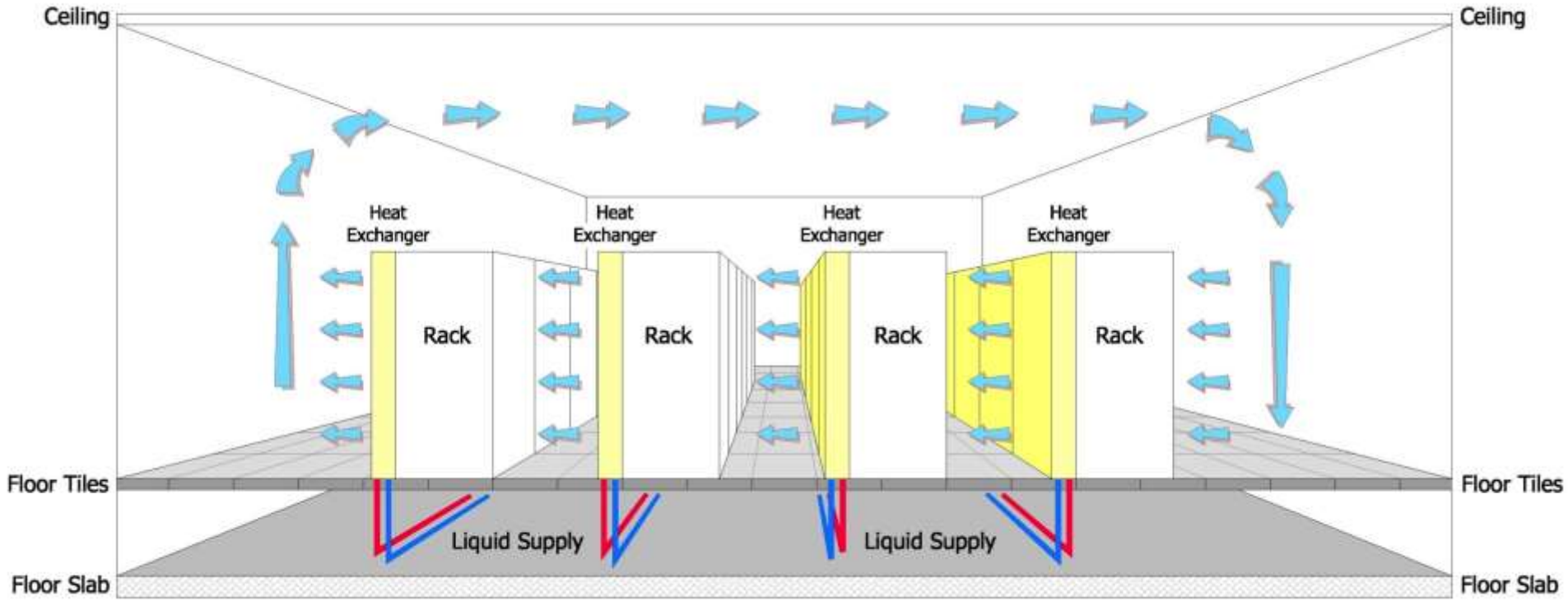
Efficient Alternatives to Under-Floor Air Distribution

- Localized air cooling systems with hot and cold isolation can supplement or replace under-floor systems
- Examples
  - Row-based cooling units
  - Rack-mounted heat exchangers
- Both options “pre-engineer” hot and cold isolation

Example – Local In-Row Based Cooling



Rack-Mounted Heat Exchangers (“Rear Doors”)



Air Management Review

Air management techniques:

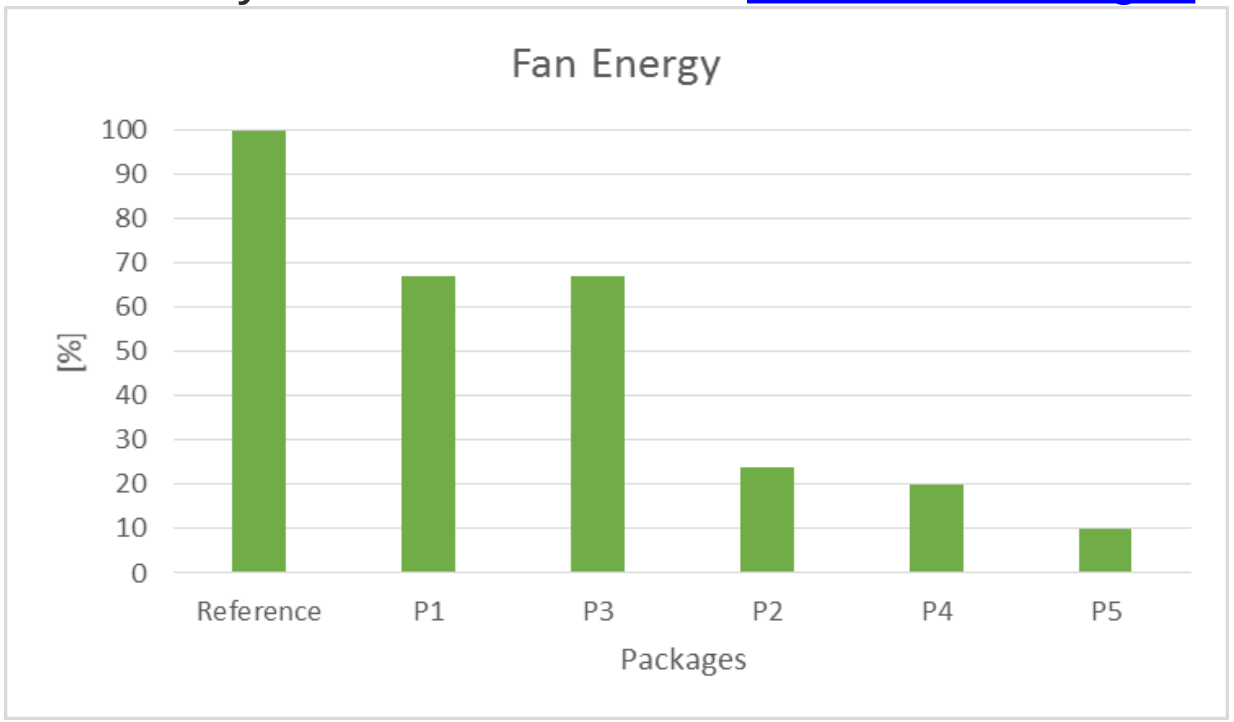
- Seal air leaks in floor (e.g., cable penetrations)
- Prevent recirculation with blanking panels in racks and between racks
- Manage floor tiles (e.g., no perforated tiles in hot aisle)
- Improve isolation of hot and cold air (e.g., return air plenum, curtains, or complete isolation)

Impact of good isolation:

- Supply airflow reduced
  - Fan savings up to 75%+
- Supply air temperature can be raised
  - Chiller efficiency improves
  - Greater opportunity for economizer operation (“free” cooling)
- Cooling and raised-floor capacity increases.

Coming Attraction: Air Management Packages

- Develop prescriptive air management “packages” through computer modeling, targeting small data centers
- Estimate energy savings
- Look-up tables with existing and potential AM strategies
- Availability December 2019 on datacenters.lbl.gov



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John Sasser

Sabey Data Centers

U.S. DEPARTMENT OF ENERGY

Air Management Solutions – Sabey's Experience

Better Buildings Webinar

Tuesday, June 4th, 2019

SABEY
Data Centers

Sabey Data Centers – Who We Are

Solution 1: Migrate to Colocation

Modern colocation providers

- May operate with high efficiency (and reliability)
  - Not all Colos are the same
  - Dig in with questions on specific operational approach (e.g. containment requirements) and actual efficiencies achieved

- Provide remote hands services
  - Racking-and-stacking equipment,
  - Cable management,
  - Blanking plate installation,
  - Containment

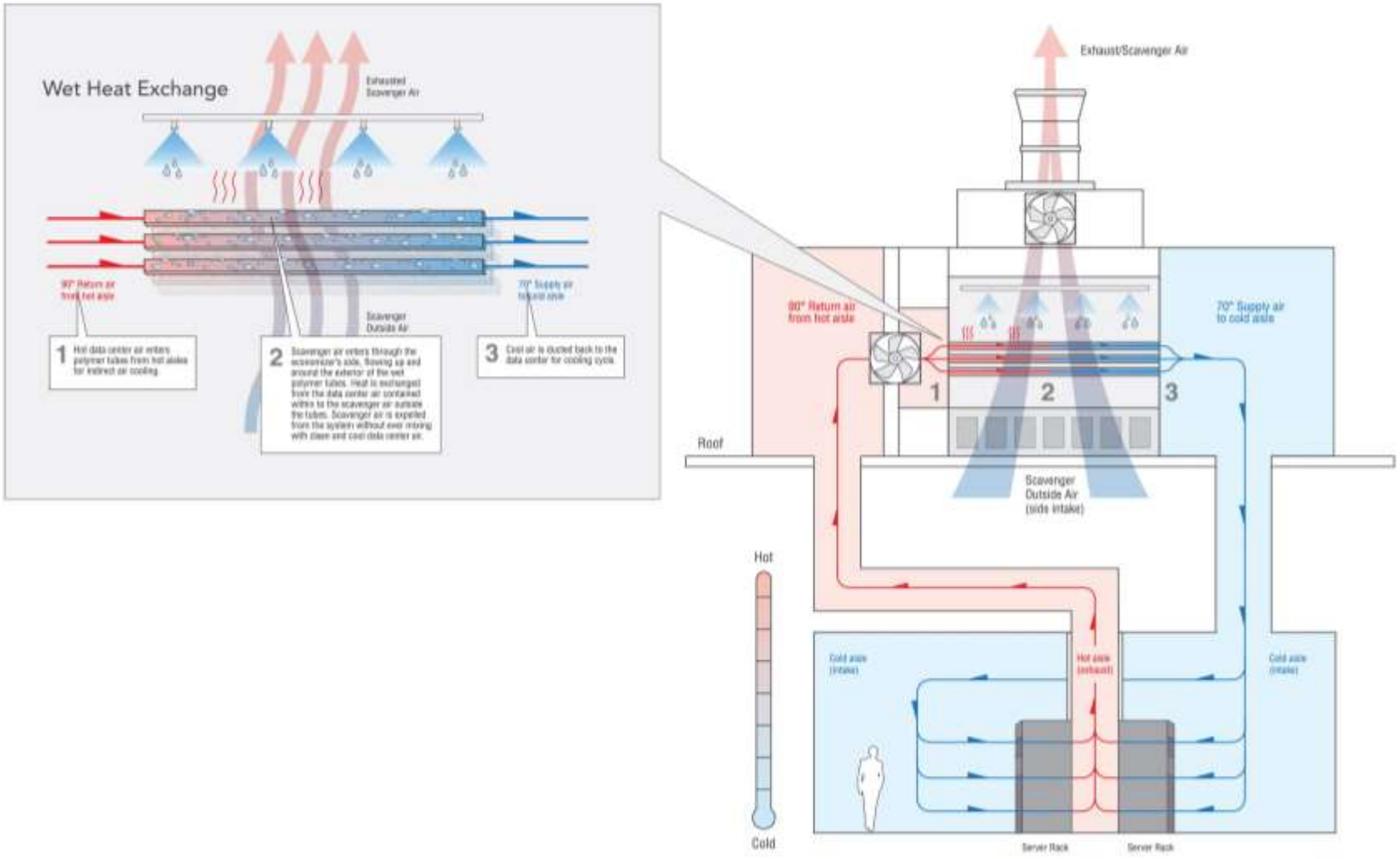
Efficiency Comparisons

- Latest Uptime Institute Survey – Average industry PUE = 1.67

- Sabey:
  - Most efficient data center average annual = 1.13
  - Portfolio weighted average annual = 1.32

- Sabey practices
  - Hot aisle containment required
  - Some form of economizer
  - Variable speed fans; fan speed controlled based on differential pressure
  - On slab (no raised floor)
  - High efficiency UPS

Indirect Economizer Cooling

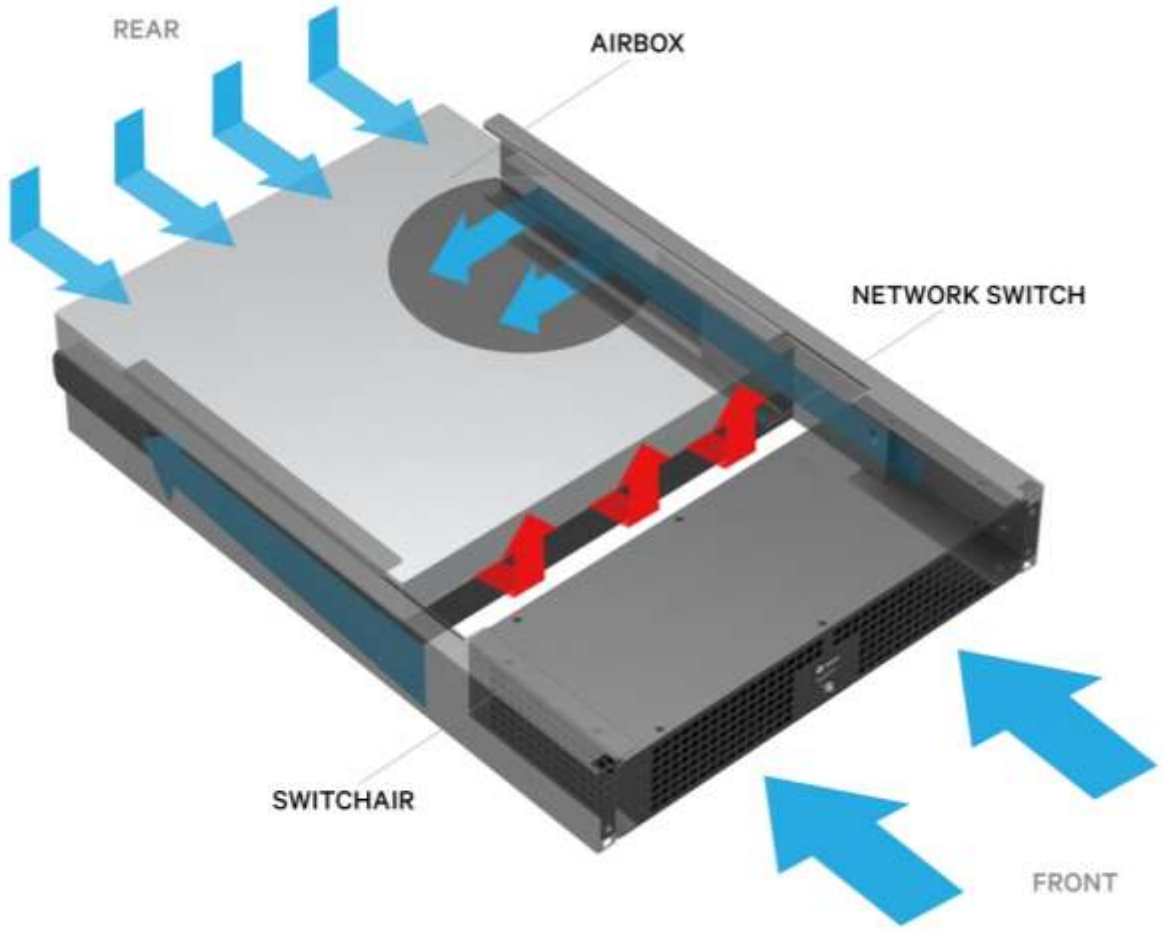


Solution 2: Improve Existing Data Center

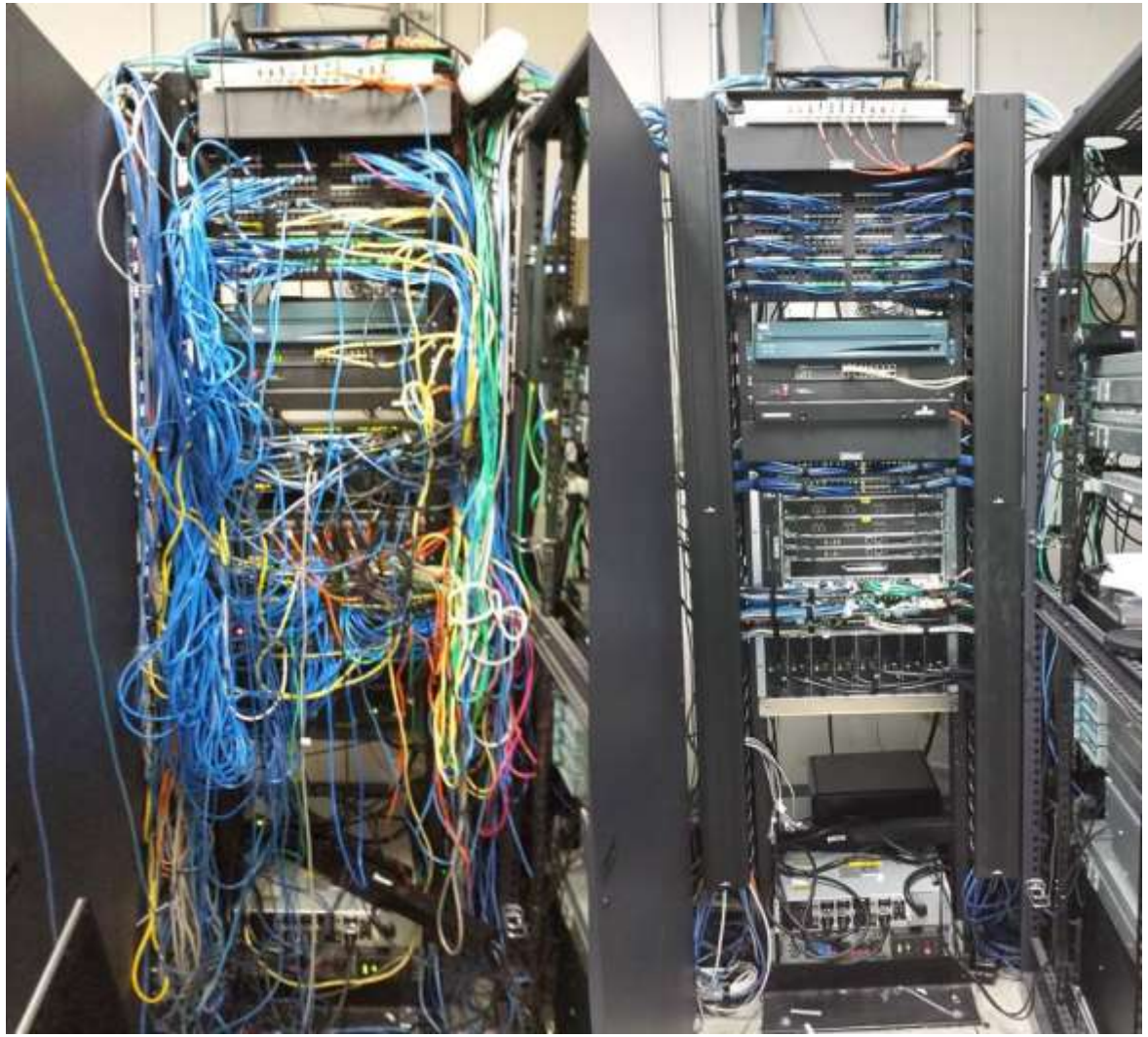
- Hot aisle / cold aisle
- Blanking plates
- Network switches – supplemental ducting
- Cable management
- Containment
- System controls
- CRAH/CRAC/AHU ducting
- Controls

Switch Airflow Management

- Vertiv Geist Switchair – example of a commercially available solution for managing airflow
- Even better – order switches with correct front to back airflow



Cable Management



Poorly dressed cables may partially block airflow from server fans, reducing their effectiveness

Hot Aisle vs Cold Aisle Containment

Controls

- Return temperature control
  - Formerly default mode of CRAH/CRAC units
  - Old/discredited
- Precision temperature control
- **Differential pressure control**
- Better airflow management enables more efficient control strategies
  - Lowering fan energy use
  - Increasing use of economizer
  - Increasing efficiency of chiller plant (if applicable)

Q&A

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Better Buildings Webinar Series

STRAIGHT TALK: TALKING TO MULTIFAMILY TENANTS ABOUT UTILITY BENCHMARKING

Tuesday, October 1, 2019 | 3:00 - 4:00 PM ET

REGISTER TODAY

This webinar will identify strategies for obtaining tenant consent to share their utility data; it will also explore ways to engage multifamily residents about the benefits of energy efficiency upgrades.


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