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Relationship Between Equipment Reliability and Energy Efficiency

ENERGY STAR Conference on
Enterprise Servers and Data Centers: Opportunities for Energy Savings
Sunnyvale, CA, February 1, 2006

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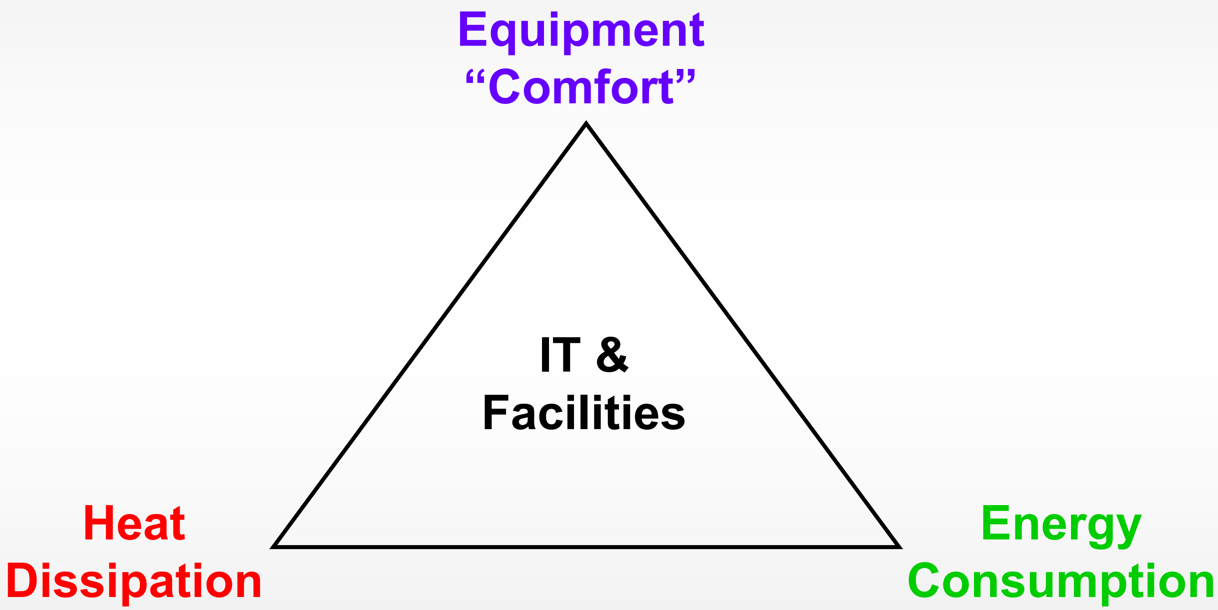
Challenge



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Today's Presentation

- Equipment Failure Modes
- Environmental Specifications
- Equipment "Comfort"—RCI
- Energy Efficient Servers
- Airflow Management
- Air-Side Economizers
- Liquid Cooling
- Maintainable Environments
- The Data Center of the Future

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Some Equipment Failure Modes

- **Low RH**
  - Electrostatic Discharge
- **High RH**
  - Hygroscopic Dust Failures
  - Corrosion
- **Airborne Particles**
  - Hygroscopic Dust Failures
  - Corrosion
- **Low Temperature**
  - Timing
  - Hygroscopic Dust Failures
- **High Temperature**
  - Diffusion
  - Corrosion
- **Temperature Cycling**
  - Thermo-Mechanical Fatigue
- **Temperature Shock**
  - Multiple
- **Volatile Organic Compounds**
  - Contact Erosion

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Equipment Costs

"People are really scared that they are going to implement an efficiency measure that saves $10,000 and cause an equipment failure that costs $2 million"

Source: Building Operating Management (2005)

A single fully loaded blade server rack can cost well above $500,000… For example, to fill an industry standard rack with IBM BladeCenter HS20 Performance blades will cost $530,000.

Source: IBM BladeCenter (2006)

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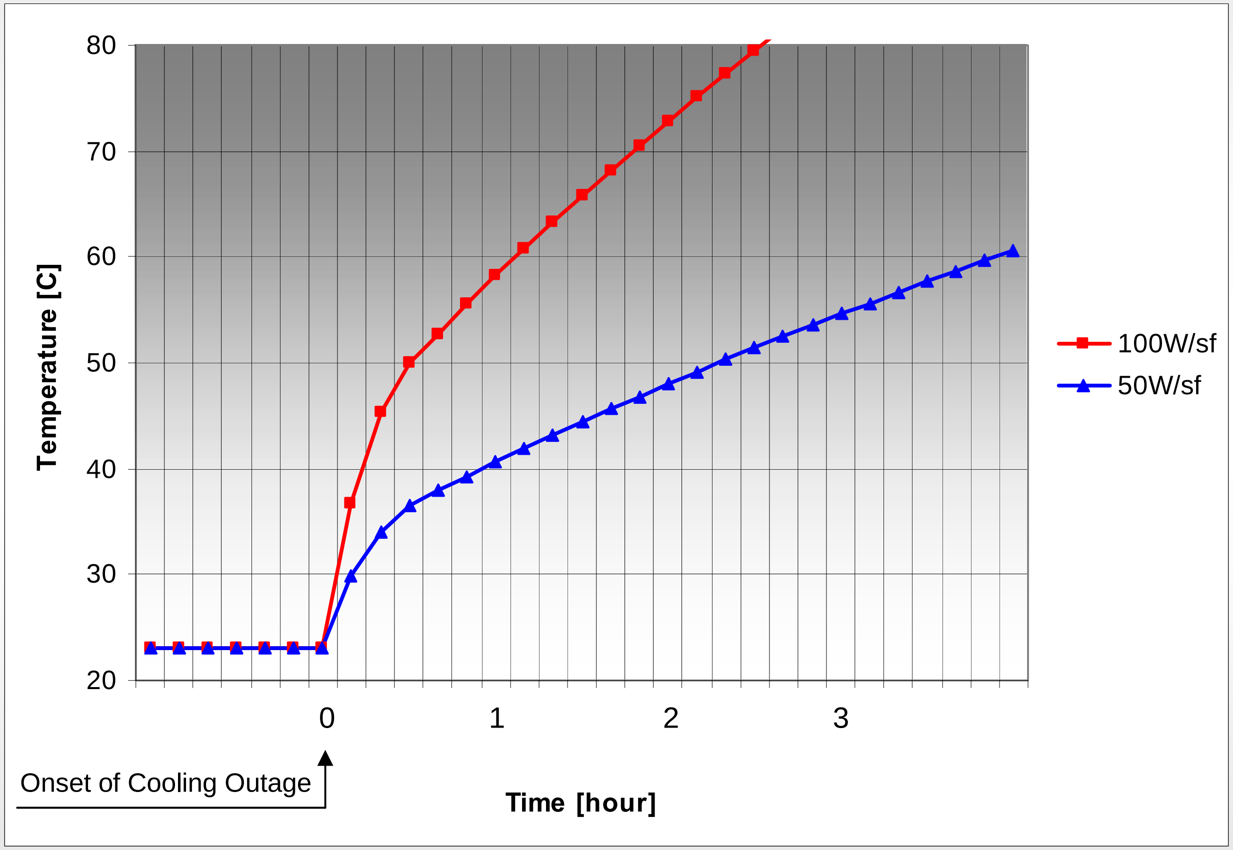
Temperature Shock



<u>Compare</u>
Liquid cooled cabinets with $> 2000\ W/ft^2$

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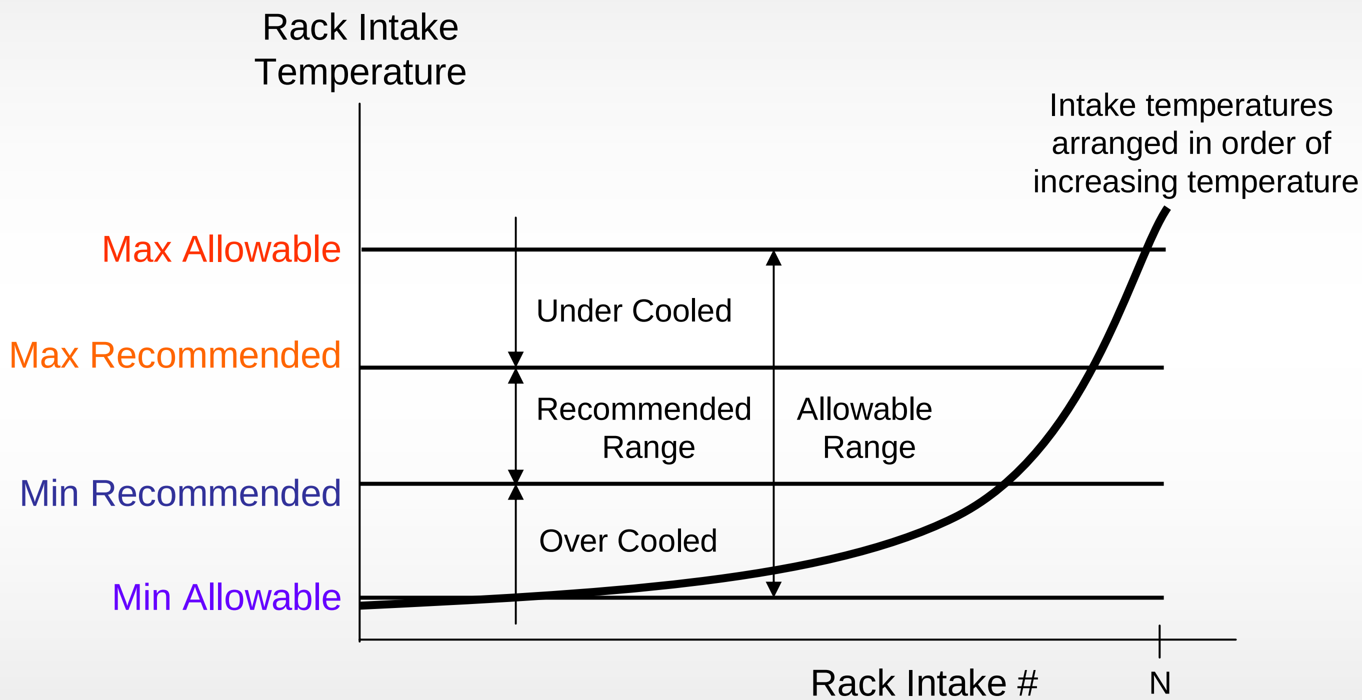
Low/High Temperatures



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Operating Protocols

You can relax the temperature and humidity ranges for Data Centers more than people have traditionally thought.

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Environmental Specifications

(@ Rack Air Intake)	Recommended (Facility)	Allowable (Equipment)
Temperature		
Data Centers	20° – 25°C	15° – 32°C
Telecom NEBS	18° – 27°C	5° – 40°C
Humidity (RH)		
Data Centers	40 – 55%	20 – 80%
Telecom NEBS	Max 55%*	5 – 85%

* Assumes Personal Grounding

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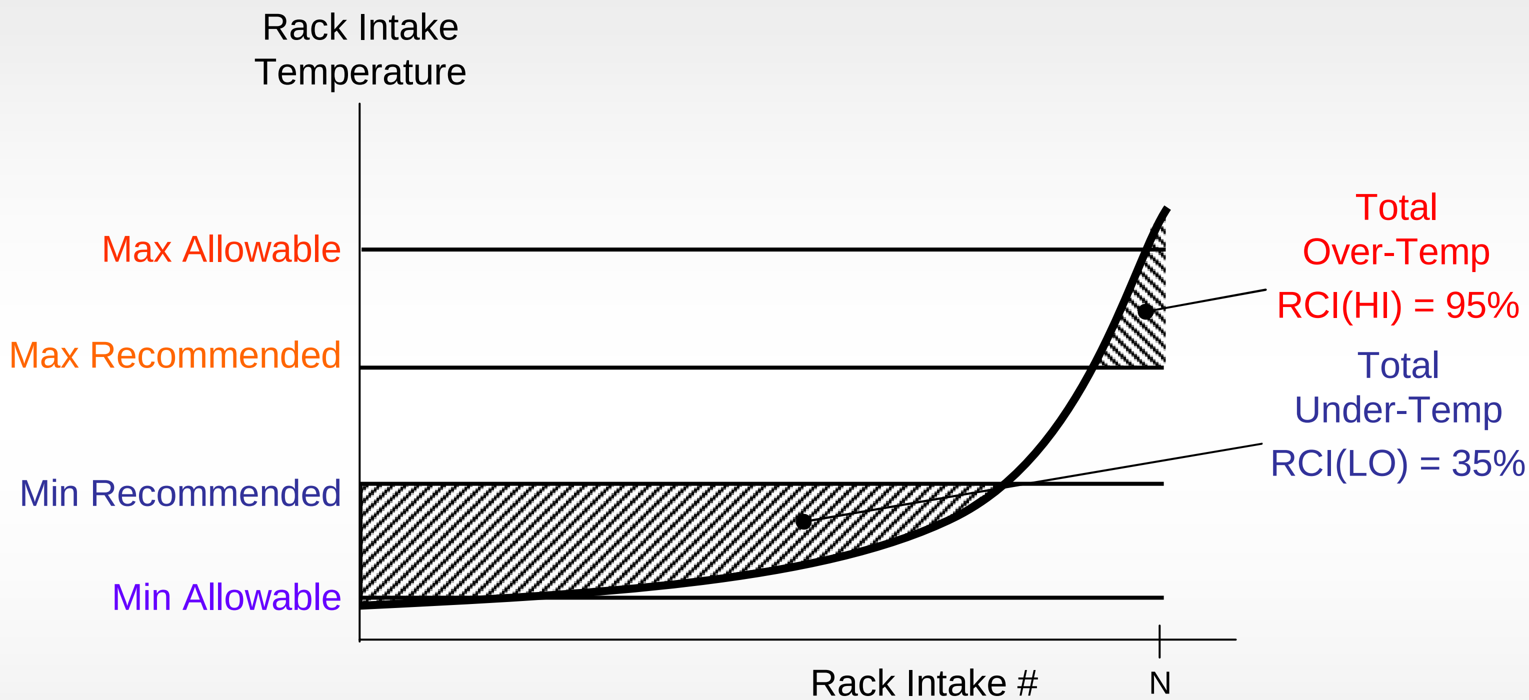
Rack Cooling Index (RCI)



- RCI is a measure of compliance with Temperature Specifications
- 100% mean ideal conditions; no over- or under-temperatures
- Free download of RCI paper at www.ancis.us

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Rack Cooling Index (RCI)

Design Equipment Environments. CFD modeling combined with the RCI provides a standardized method for evaluating and reporting environmental and energy solutions.

Provide Design Specifications. Clients now have the opportunity to specify a certain level of thermal comfort in an objective and standardized way, e.g., RCI > 95%.

Monitor Equipment Environments. Real-time monitoring of the environment is feasible by installing temperature sensors that mimics the equipment intake conditions.

Help Product Development/Marketing: The RCI can effectively help demonstrate the benefit of a cooling solution. A product with an RCI at or near 100% should be marketed as such.

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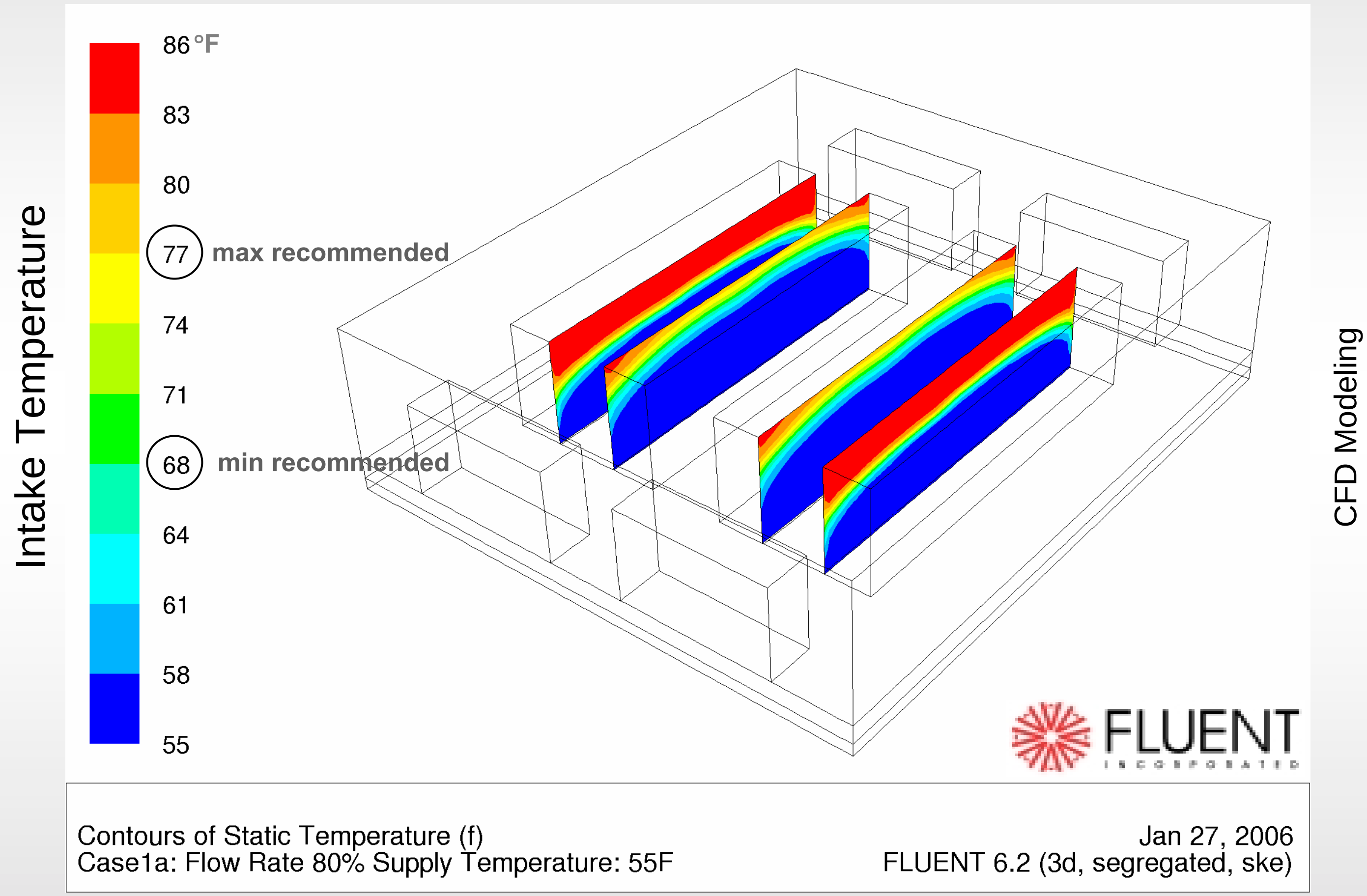
Example: 80% Flow Rate, 55°F SAT



Source: Kishor Khankari (Fluent) and ANCIS

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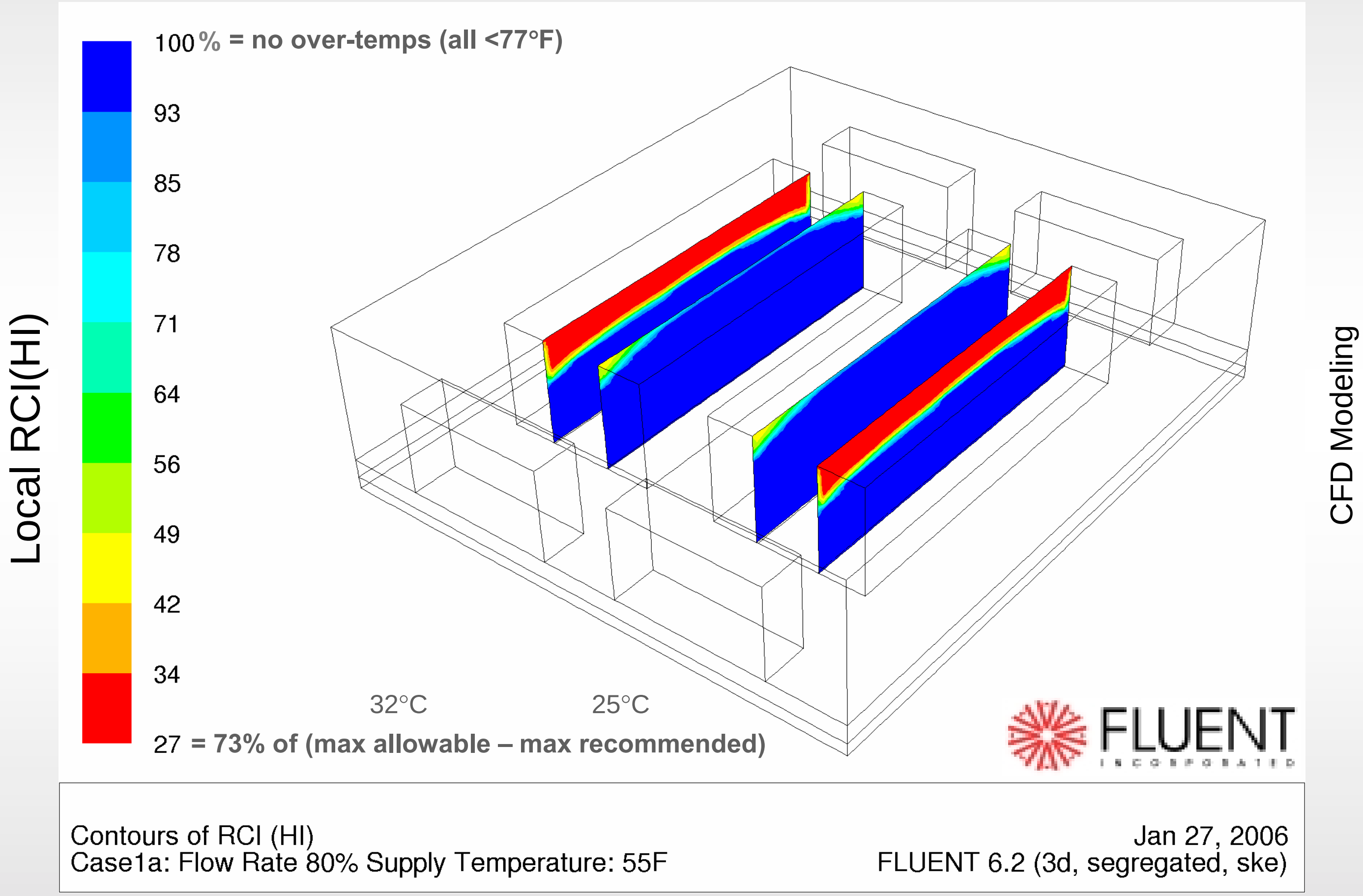
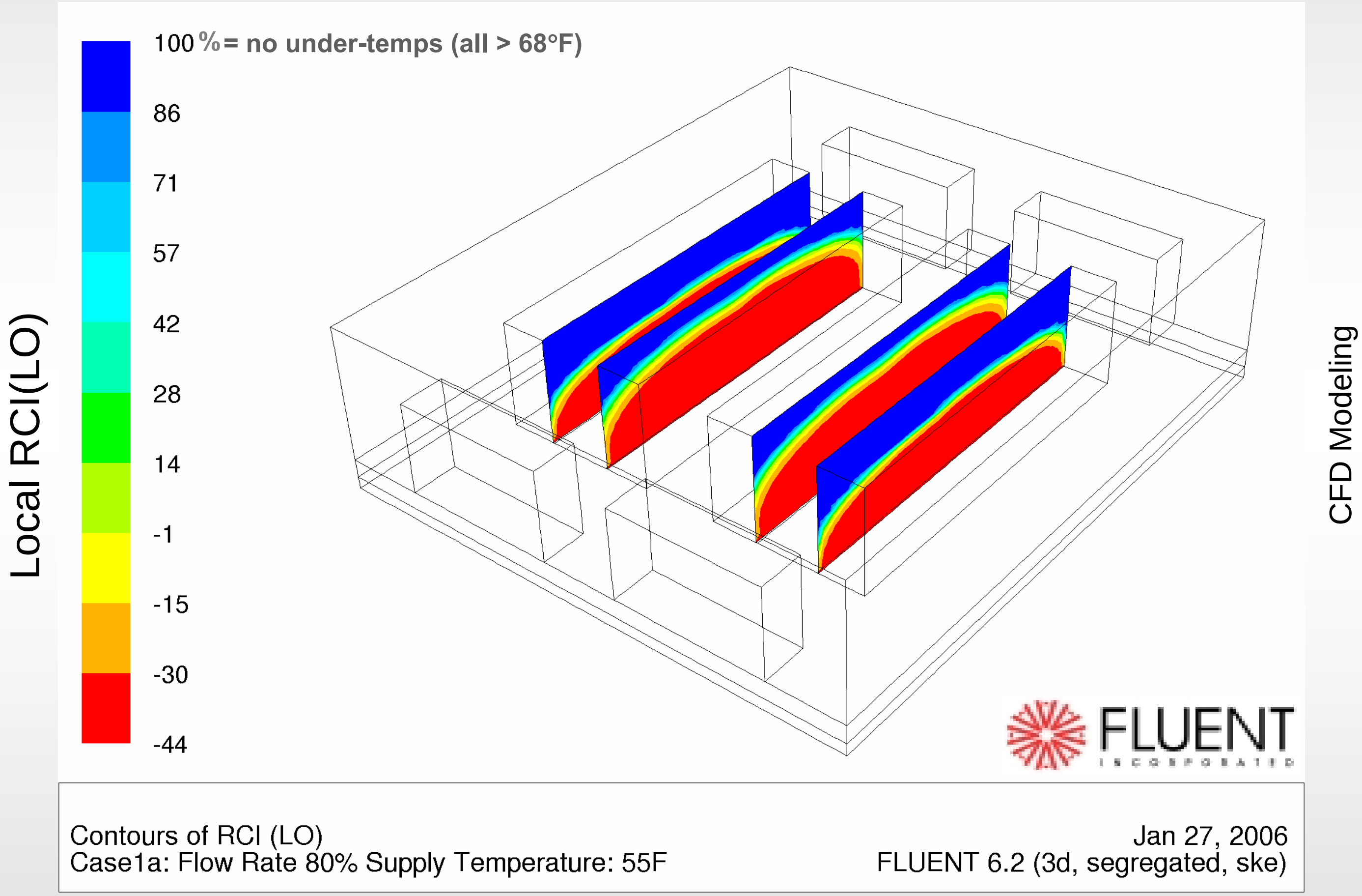
RCI(HI) = 90%



Source: Kishor Khankari (Fluent) and ANCIS

RCI(LO) = 20%



Source: Kishor Khankari (Fluent) and ANCIS

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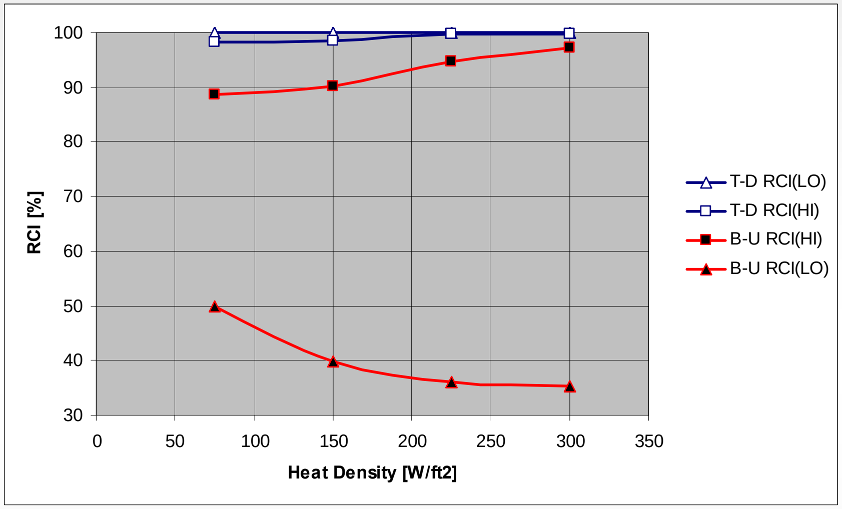
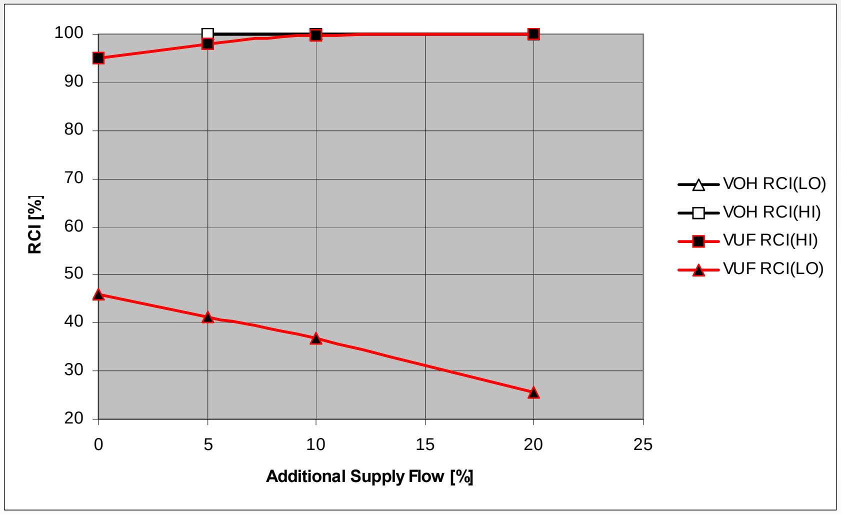
Top-Down vs. Bottom-Up





Data: Magnus K. Herrlin (2005)

Data: Herbert Sorell (2005)

Remedy: Higher Supply Air Temperature and Supply Airflow Rate

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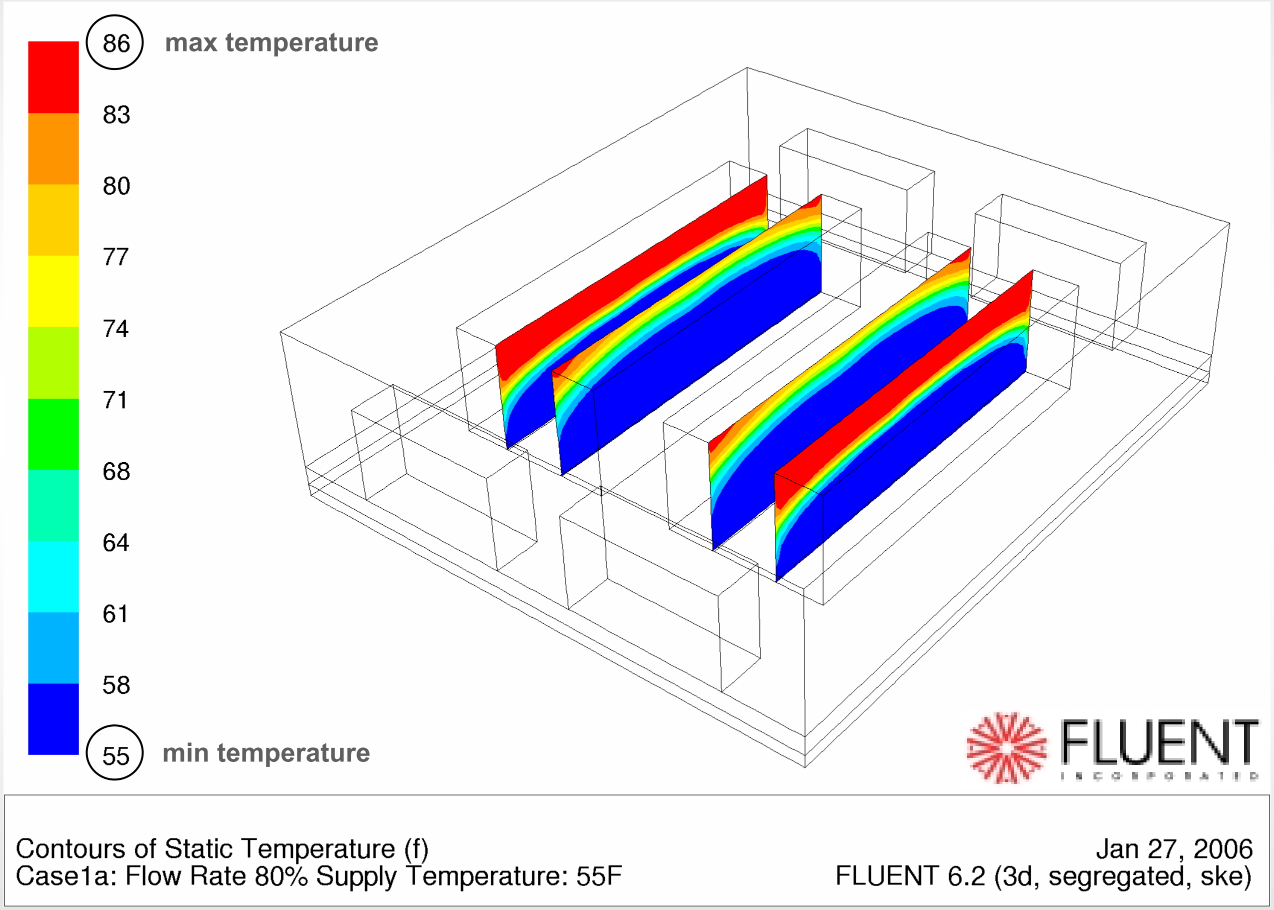
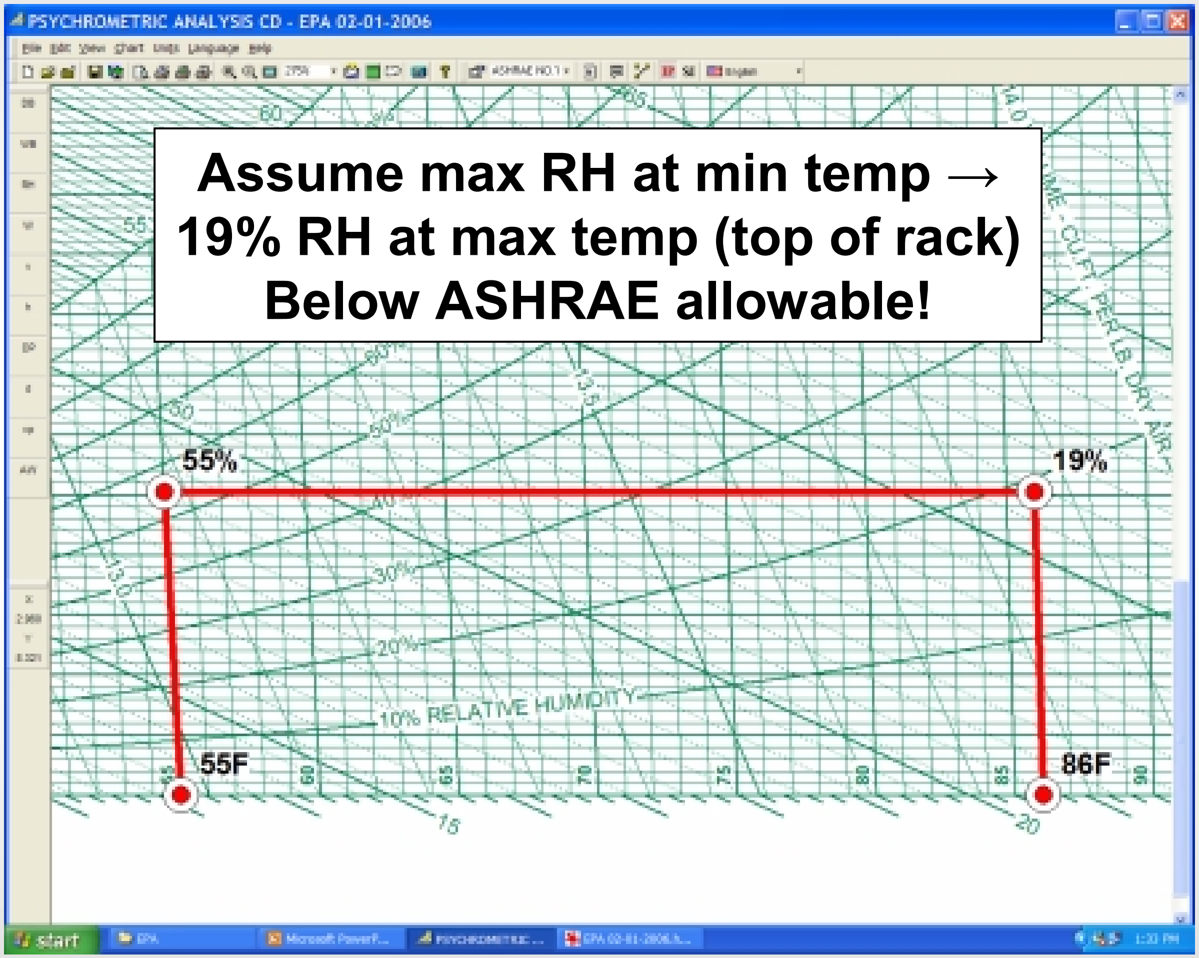
Relative Humidity for Bottom-Up



Source: Kishor Khankari (Fluent) and ANCIS

Relative Humidity for Bottom-Up



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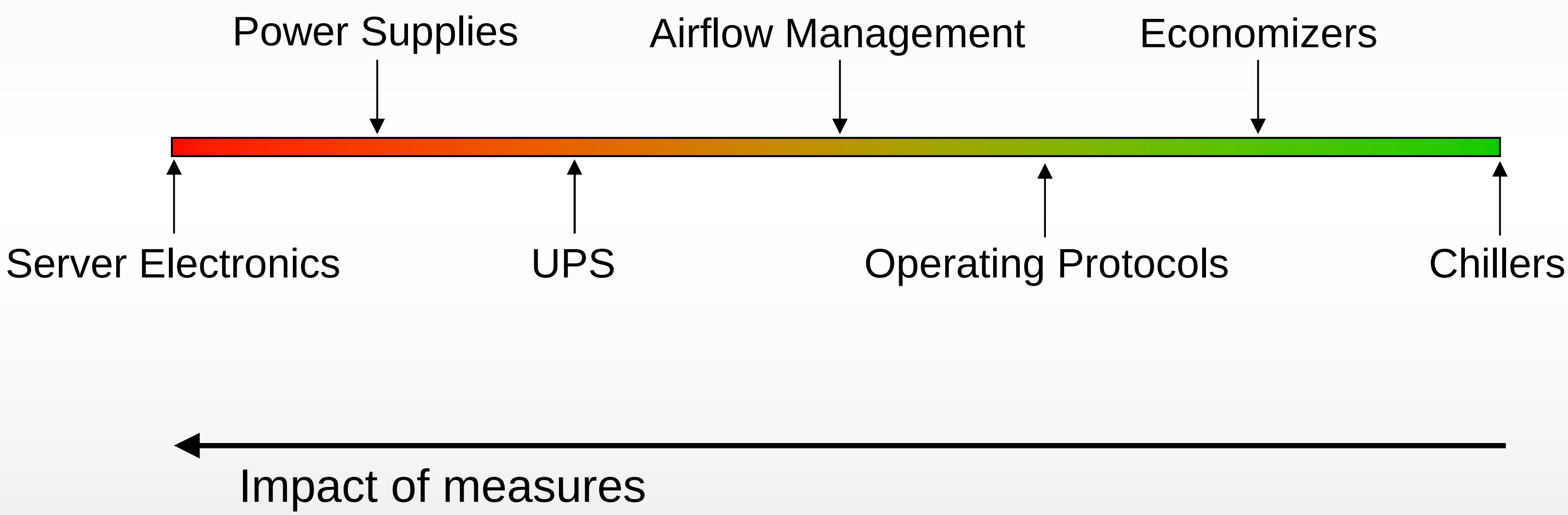
The “Food” Chain



Energy Efficient IT Equipment

“The introduction of efficient network equipment provides an unmatched cost-saving potential for telecom equipment operators.”

Source: Bell Communications Research (1996)

“If performance per watt is to remain constant over the next few years, power costs could easily overtake hardware costs…"

Source: Luiz Andre Barroso, Google (2005)

Energy Efficient IT Equipment

- No truly revolutionary technology… sorry
- Server Utilization
- Power Management
- Processor Speed
- Performance Efficiency
- Power/Performance

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Performance Efficiency

"The energy efficiency improvement for HP Superdome is 3.4 times over less than three years (performance/Watt)."

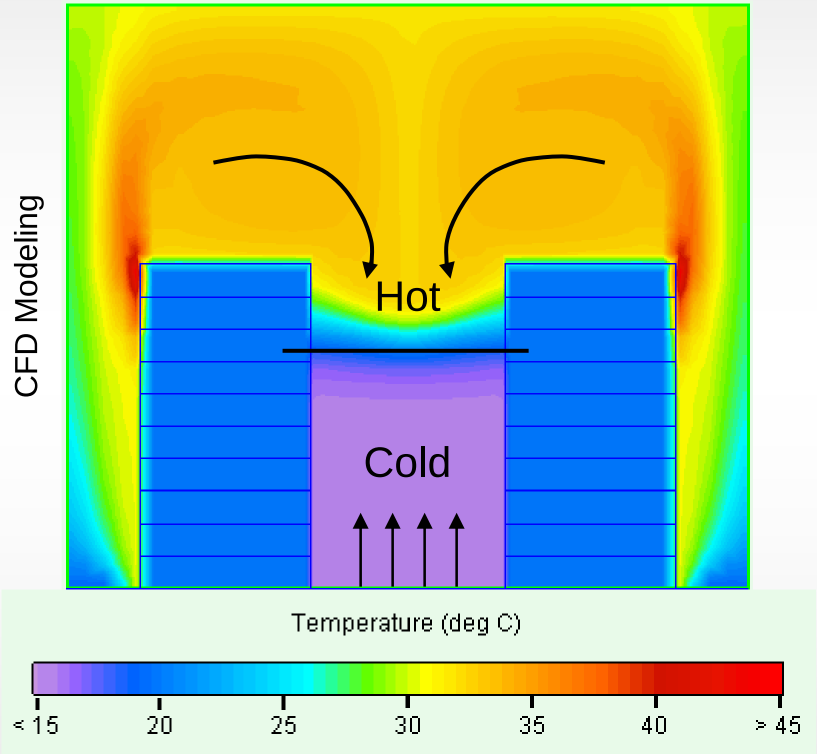
Source: Christian Belady, P.E.
HP Technology Forum,
Orlando, FL (2005)

Airflow Management

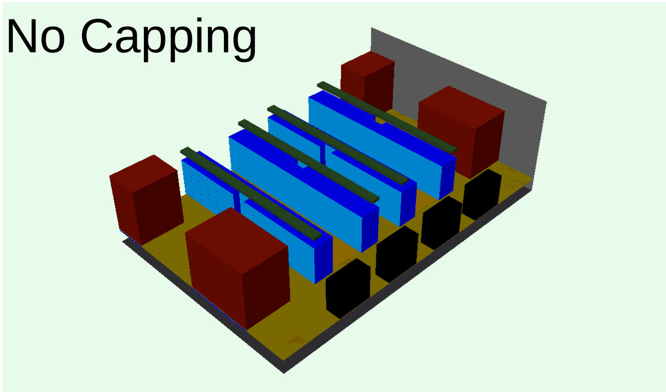
- Hot/Cold aisle configuration
  - Efficient but demanding environment
- Once-through cooling
  - Less airflow, Higher RAT, Less energy
- Constant supply temp
  - Variable supply flow rate, Less energy
- Match delta T of servers and air-handlers
  - Twice the supply flow may cost 20% extra HVAC energy
- VOH (over-head) vs. VUF (under-floor)
  - VOH generally has higher RCI, Energy might be a wash due to system dP, system Q (leakage + aisle), and SAT

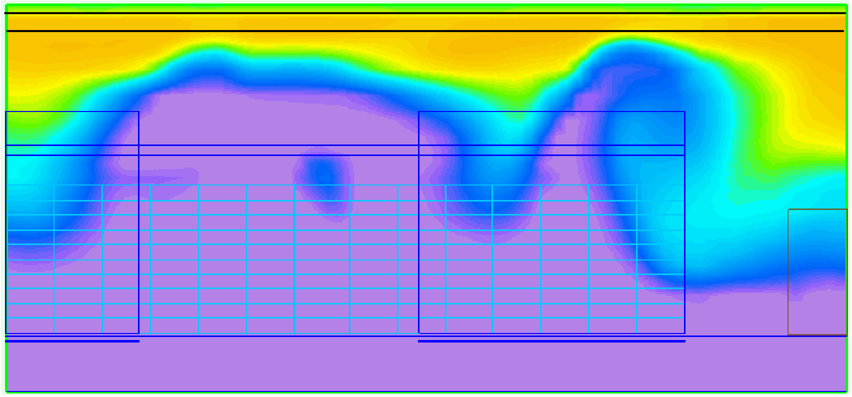
Bottom-Up Airflow Requirements

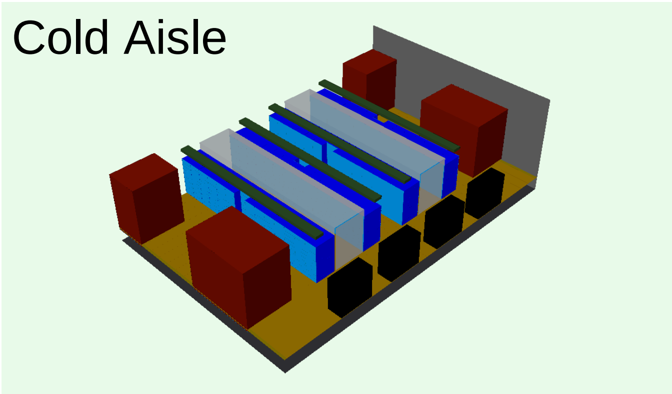
CFD Modeling

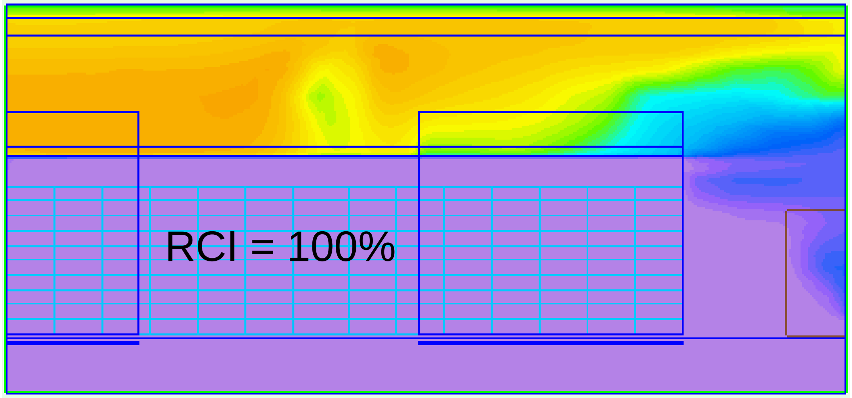


Aisle Capping









CFD Modeling

Air-Side Economizers

Most telecom central offices operate with airside economizers, but data centers generally don't. So that is an opportunity for a data center if the conditions are right and there is proper air filtration.

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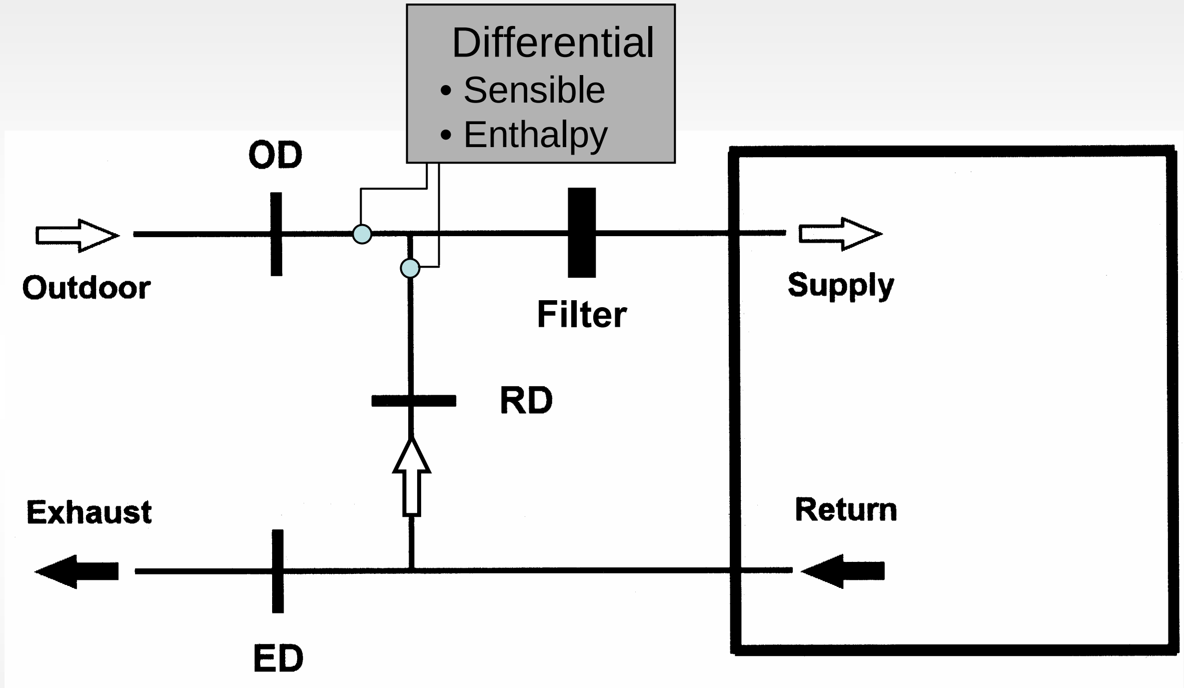
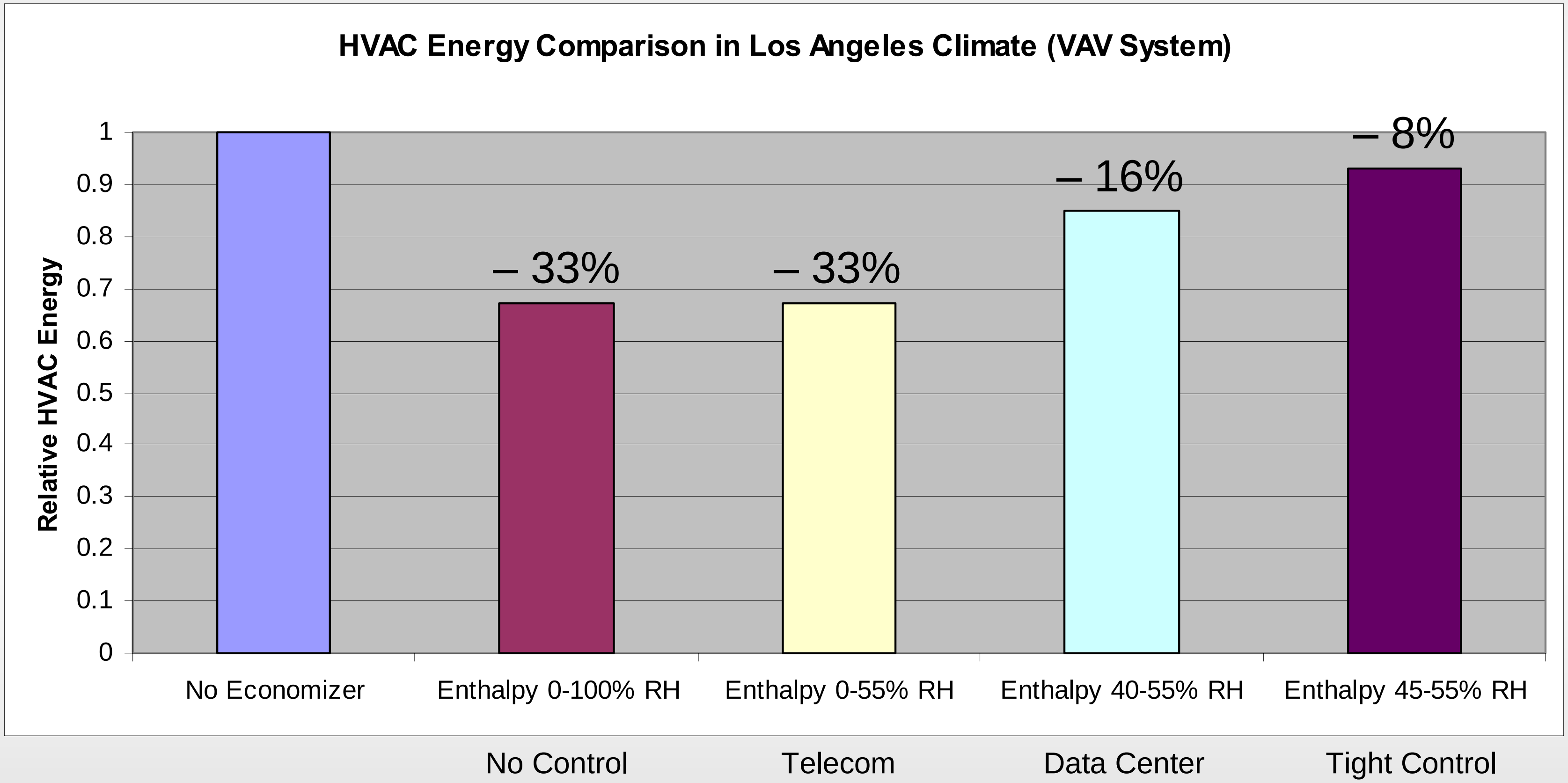
Air-Side Economizers



- High Return Air Temp Benefits Economizers
- Over-Ride Controls (extreme outdoor conditions)

Air-Side Economizers



Actual Data Center
Computer Modeled

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End User 1: 2000 COs

- Most Central Offices use air-side economizers
- Both sensible and enthalpy economizers are used
- Little problems; occasional indoor humidity swings due to rapid weather changes.
- Overall good success. Sometimes disconnected in humid and/or hot locations.
- NEBS robust equipment

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End User 2: 1200 COs

- Most Central Offices use air-side economizers
- Enthalpy economizer is most common
- No equipment failures. Dust storms in desert areas can wipe out a filter bank completely.
- All new HVAC designs are required to include air-side economizers
- Purging capabilities

Liquid Cooled Solutions

knürr
environments for electronics

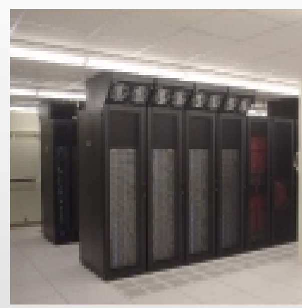
IBM

Rear Door Heat eXchanger

APC
Legendary Reliability™

SANMINA-SCI

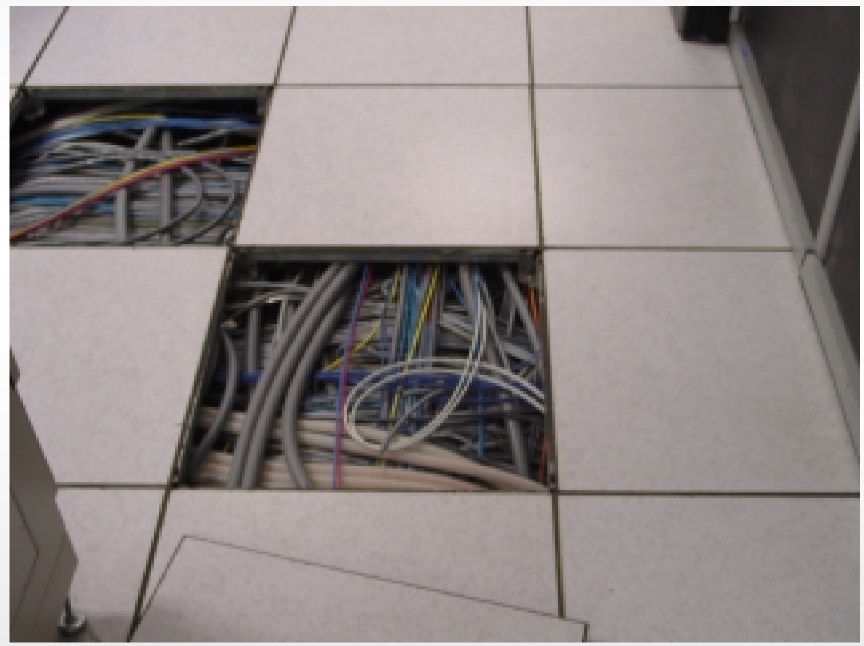
ELECTRONICS MANUFACTURING SERVICES



Liebert®

Maintainable Environments

Cabling + Air-Distribution = @!!#



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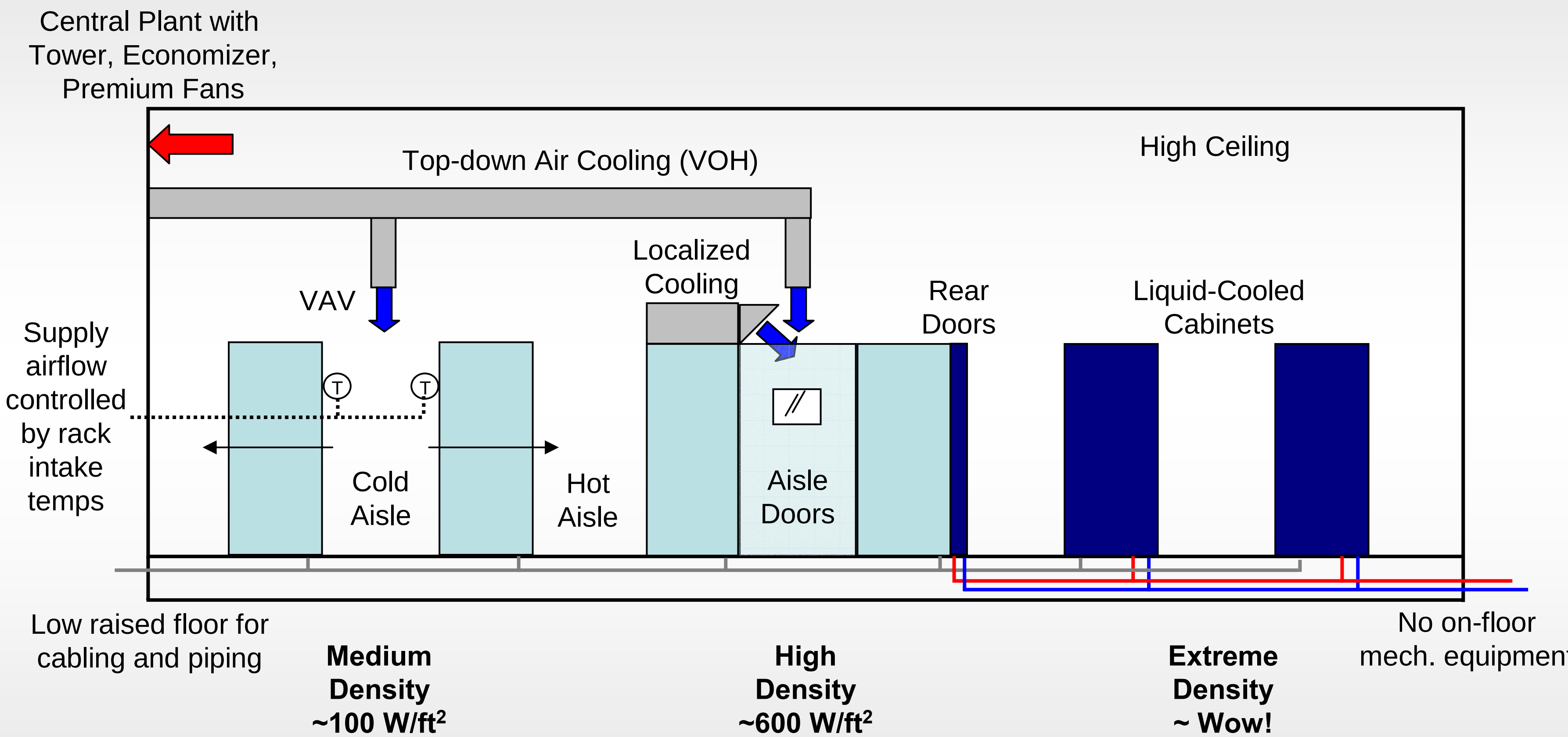
Future Data Center Requirements

- Separate different functions (cabling/cooling)
- Tiered density (spend resources where needed)
- Scalable solution (no-pain growth)
- Energy efficient (save resources)
- Maintainable (keep top-performance: thermal/energy)

The Data Center of the Future?



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Summary

- Analyze the data center as a “system”
- Operate within the environmental range
- Understand reliability implications of energy measures
- Evaluate the benefits of air-side economizers
- Use CFD modeling for air-cooled solutions
- Be aware of thermal shock risk with dense loads
- Use the RCI to prove your great cooling solution
- Design tiered and scalable solutions
- Create maintainable environments

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Thank You

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