ANCIS™

INCORPORATED

# Energy Efficiency and Effective Equipment Cooling In Data Centers

**Presentation at ASHRAE Summer Meeting**
**Quebec City, Canada, June 27, 2006**

**Magnus K. Herrlin, Ph.D., CEM**
President
ANCIS Incorporated
mherrlin@ancis.us
www.ancis.us

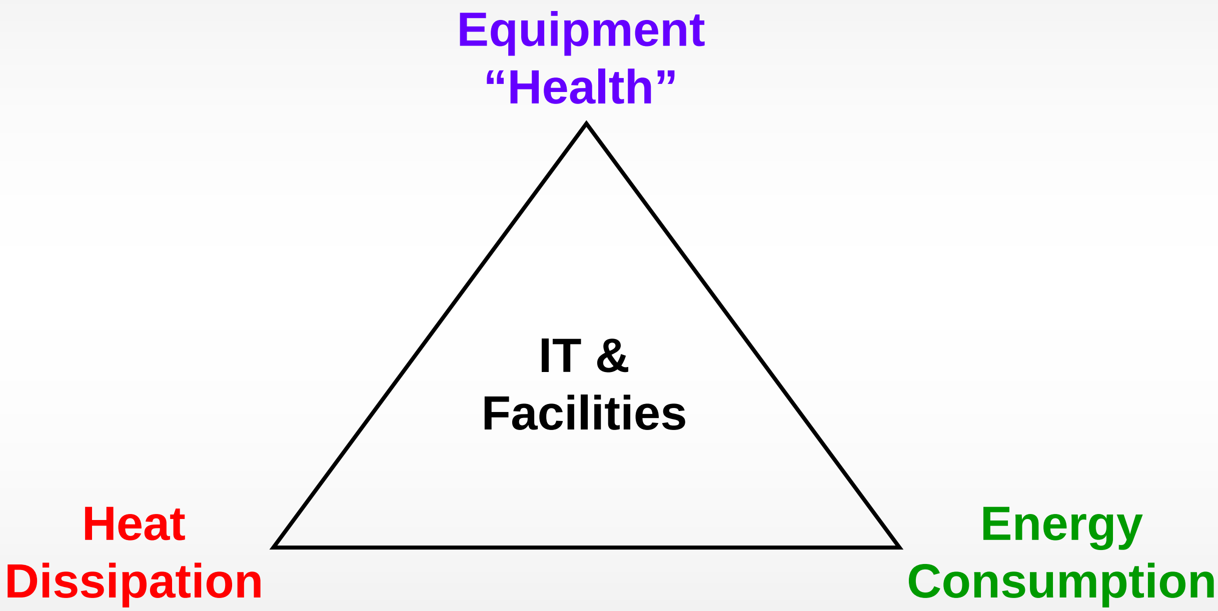
# Abstract

Not only does modern electronic equipment consume large amounts of electric energy but its heat dissipation is tremendous in historical terms.

For the end user, the cost of powering the data center is significant and providing effective equipment cooling is an ever increasing challenge.

This presentation highlights how intertwined these seemingly separate issues are. Several new concepts are discussed: ***Rack Cooling Index (RCI)***, ***Cost Functions***, and ***Gravity-Assisted Air Mixing***.

# Today’s Challenge




**The challenge is to *<u>strike a balance</u>* between these three factors.**

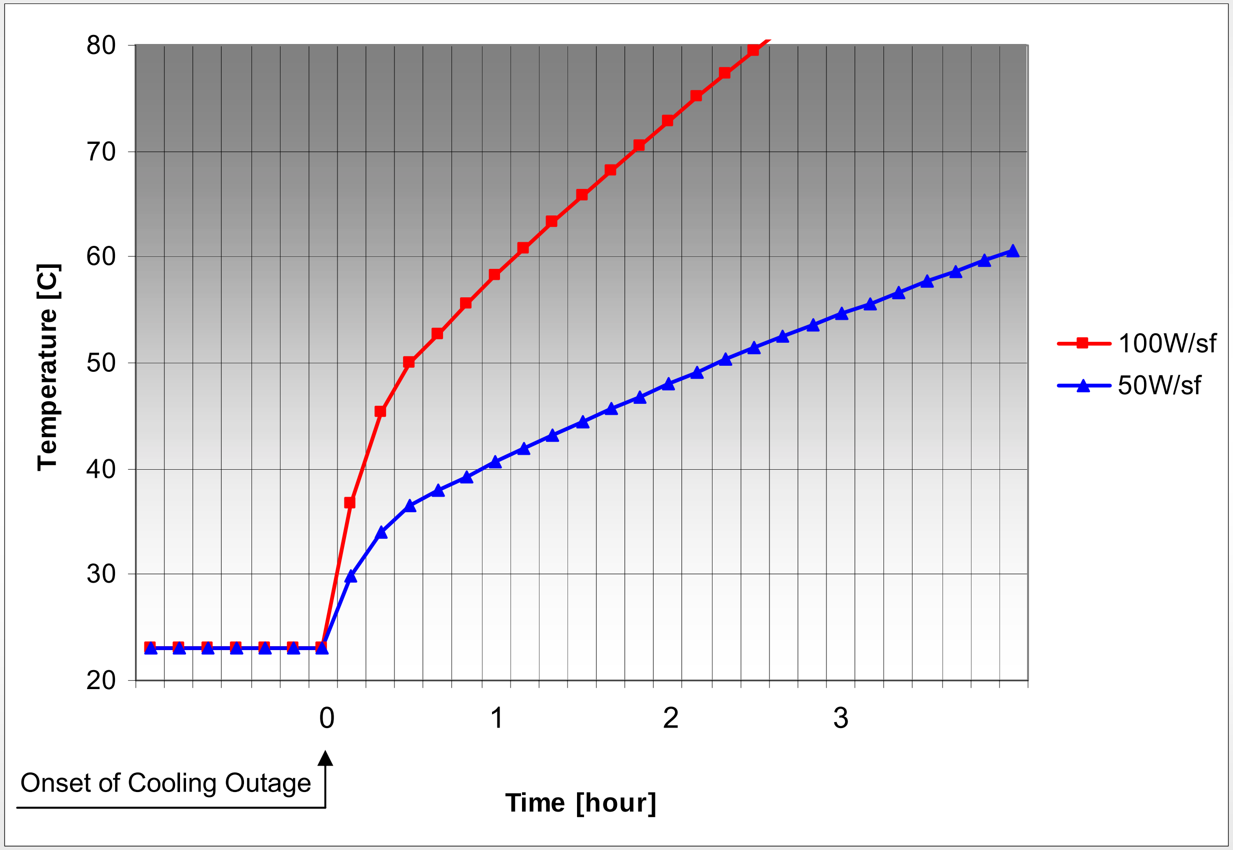
# Equipment "Health"

**Environmental parameters:**

- **Temperature**
- **Humidity**
- **VOC**
- **Particles**

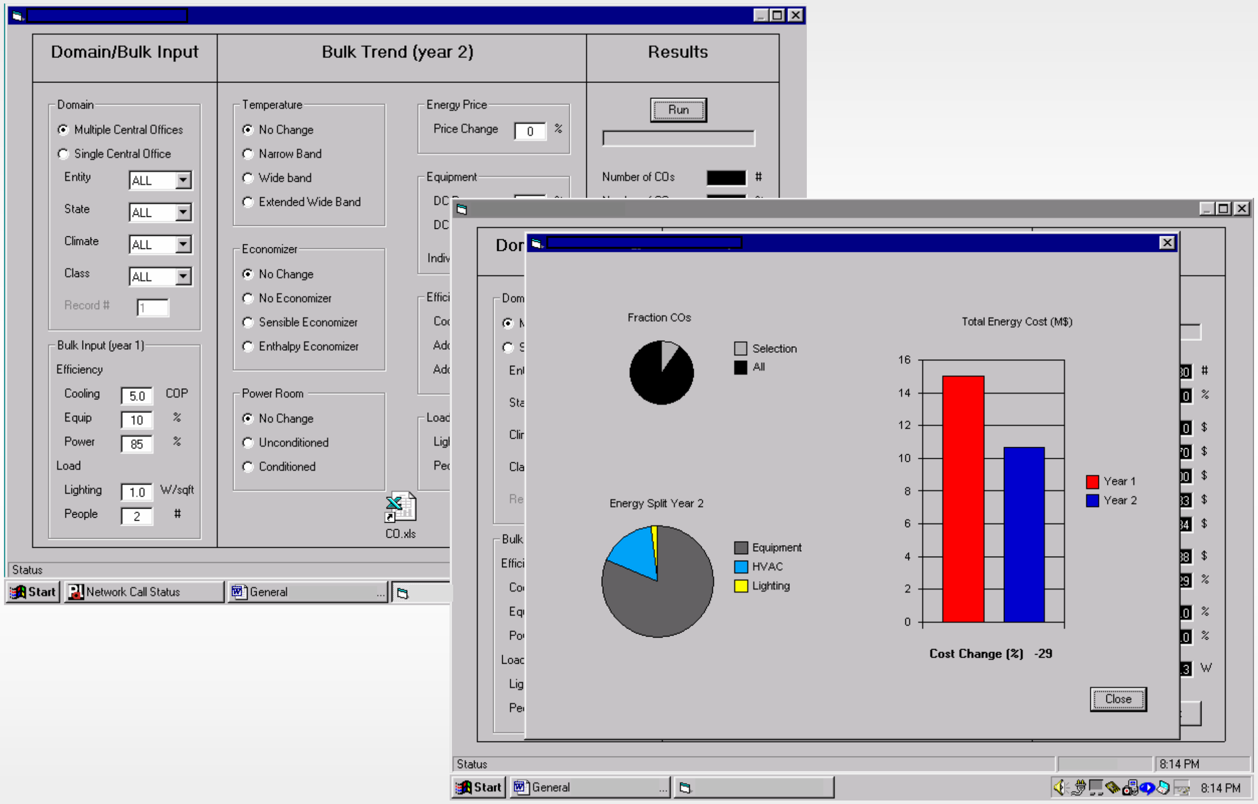
**The *<u>main task</u>* for a data center facility is to provide an adequate equipment environment; relevant metrics must be used to gauge the environment.**

# Heat Dissipation



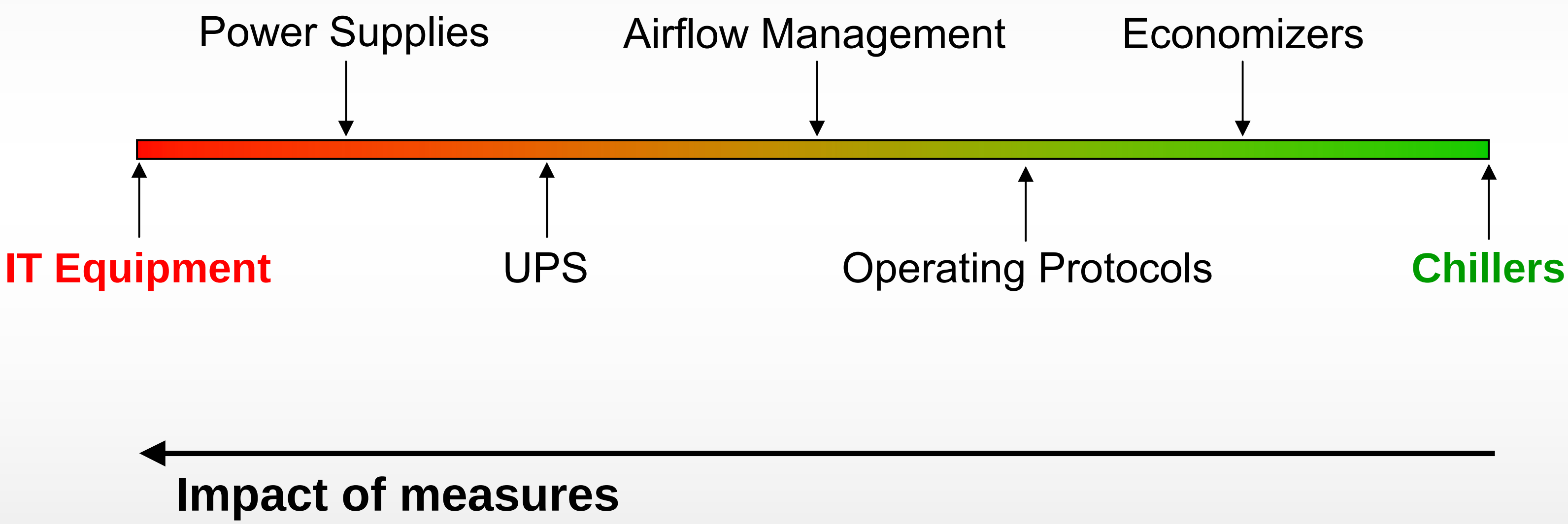

**Even modest heat densities may cause *temperature shock* during cooling system outages; redundant cooling and backup power must be in place.**

# Energy Consumption




**Simplified yet accurate energy tools provide *<u>quick evaluation</u>* of HVAC designs without an in-depth knowledge of complex energy software.**

# The Energy “Food” Chain




**The impact of IT equipment efficiency measures cascades through the food chain, the impact of chiller efficiency measures does not.**

# Energy Efficient IT Equipment

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

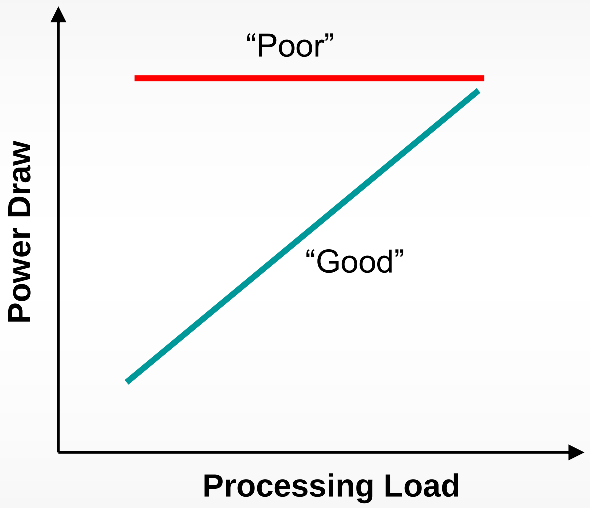
Source: Bellcore (1996)

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

Source: Google (2005)

# IT Equipment Energy Performance

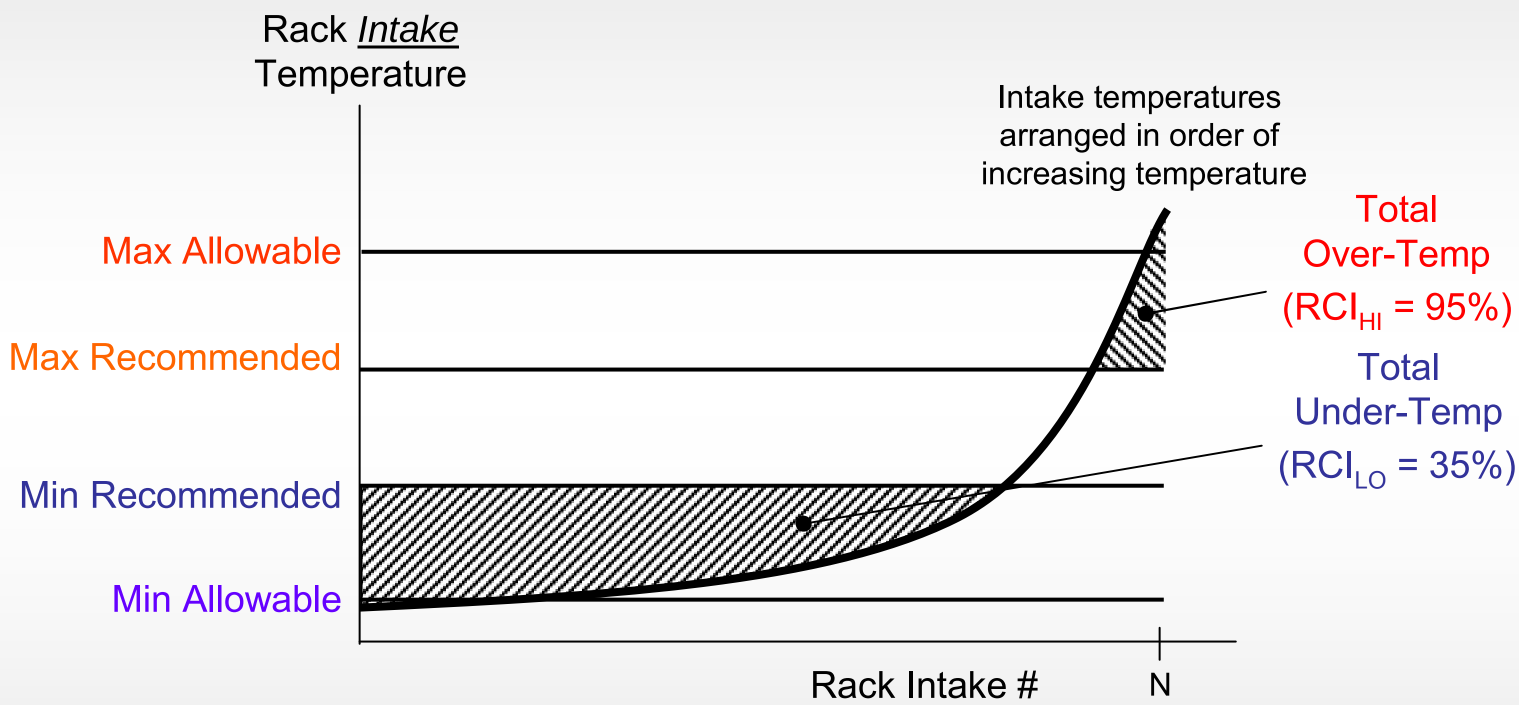
Energy metrics for IT equipment should be a top priority to encourage product development and informed customer decisions. A starting point could be to ensure a strong correlation between Power Draw and Processing Load.



# Data Center Design Issues

- “Room” temperature vs. intake temperature
- Industry temperature specifications
- Metric for *compliance* with temp. specifications
- Metric for energy efficiency

# Temperature Specifications




***Compliance*** **with (industry)** ***intake*** **temperature** ***specifications*** **is the ultimate cooling performance metric; the Rack Cooling Index (RCI) is such a metric where RCI = 100% mean ideal conditions.**

# What Is Considered a "Good" RCI?

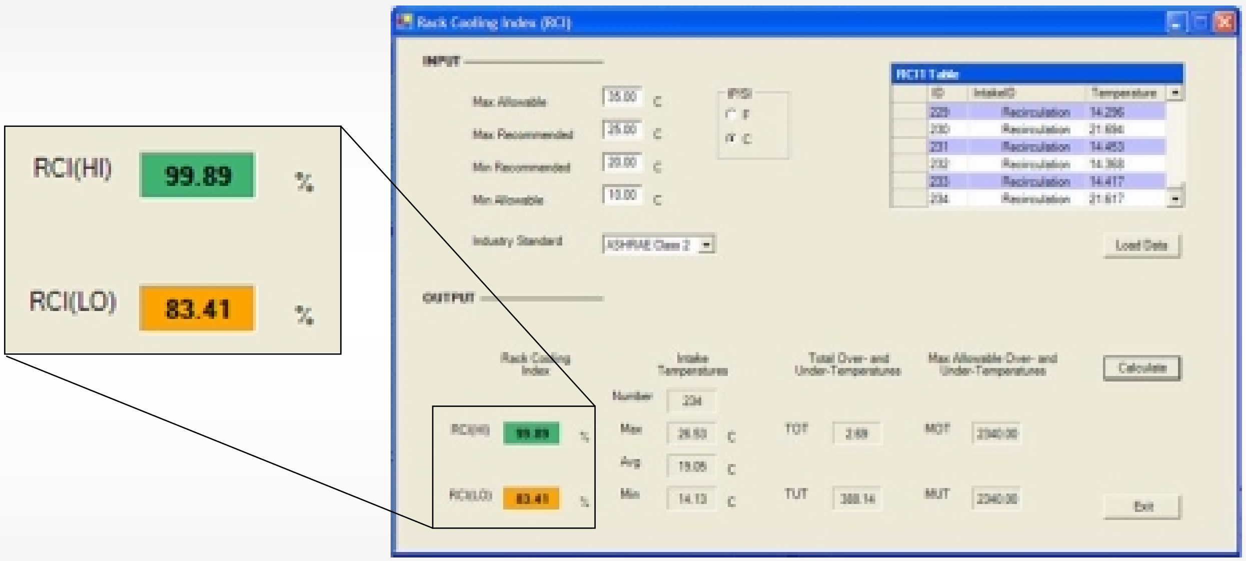
RCI=100% mean ideal conditions; no over- or under-temperatures, all temperatures are within the *recommended* temperature range.

| Rating | RCI |
|---|---|
| Ideal | 100% |
| Good | ≥91% |
| Acceptable | 81-90% |
| Poor | ≤80% |

Reference: Herrlin (2005)

Herrlin, M. K. 2005. "Rack Cooling Effectiveness in Data Centers and Telecom Central Offices: The Rack Cooling Index (RCI)" ASHRAE Transactions, Volume 111, Part 2.

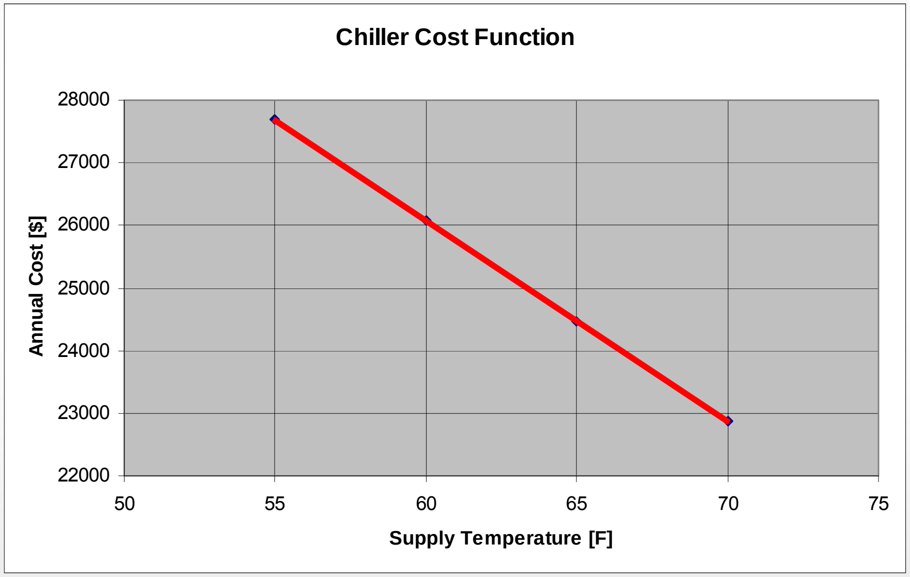
# How Is the RCI Calculated?




**The RCI can easily be calculated from measured or modeled intake temperature data by using *RCI software*.**

# Cost Functions

Since the costs associated with improving the RCI needs to be known, the concept of “Cost Functions” was developed based on costs to cool the data center facility.




Example of Cost Function:
Annual chiller operating cost as a function of supply air temperature

**By combining the Rack Cooling Index (RCI) with Cost Functions, a practical tool was born to design and evaluate data centers for optimal rack cooling effectiveness _**and**_ HVAC cooling costs.**

# What Can the RCI Be Used For?

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

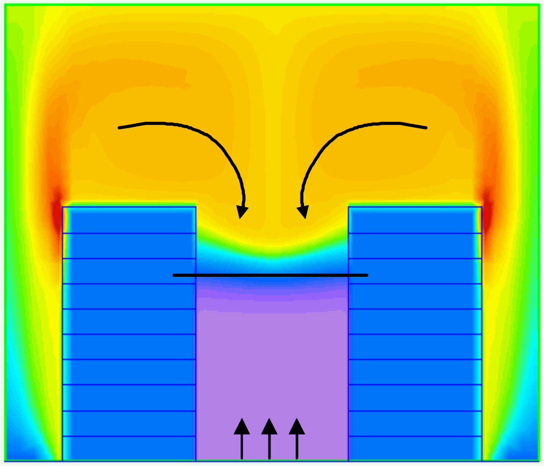
**Provide Design Specifications**. Clients now have the opportunity to specify a certain level of thermal health in an objective and standardized way, e.g., RCI > 95%.

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

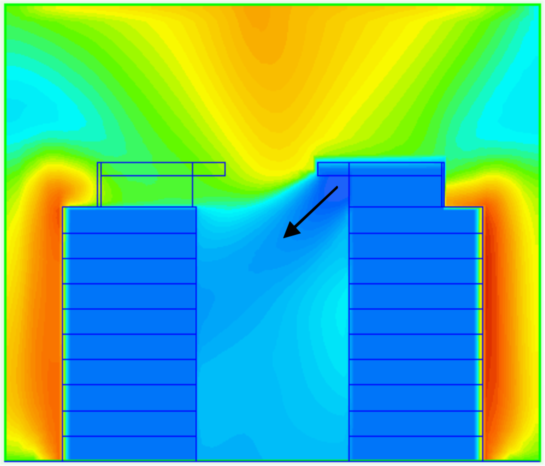
**Help Product Development/Marketing**: The RCI can demonstrate the benefit of a cooling solution. A product or solution with an RCI at or near 100% should be marketed as such.

# Gravity-Assisted Air Mixing

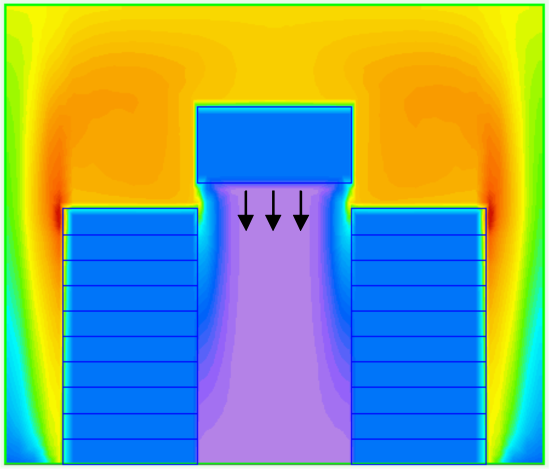
Exploring gravity's role for three cooling systems
using the Rack Cooling Index (RCI)



Bottom-Up



Top-Down



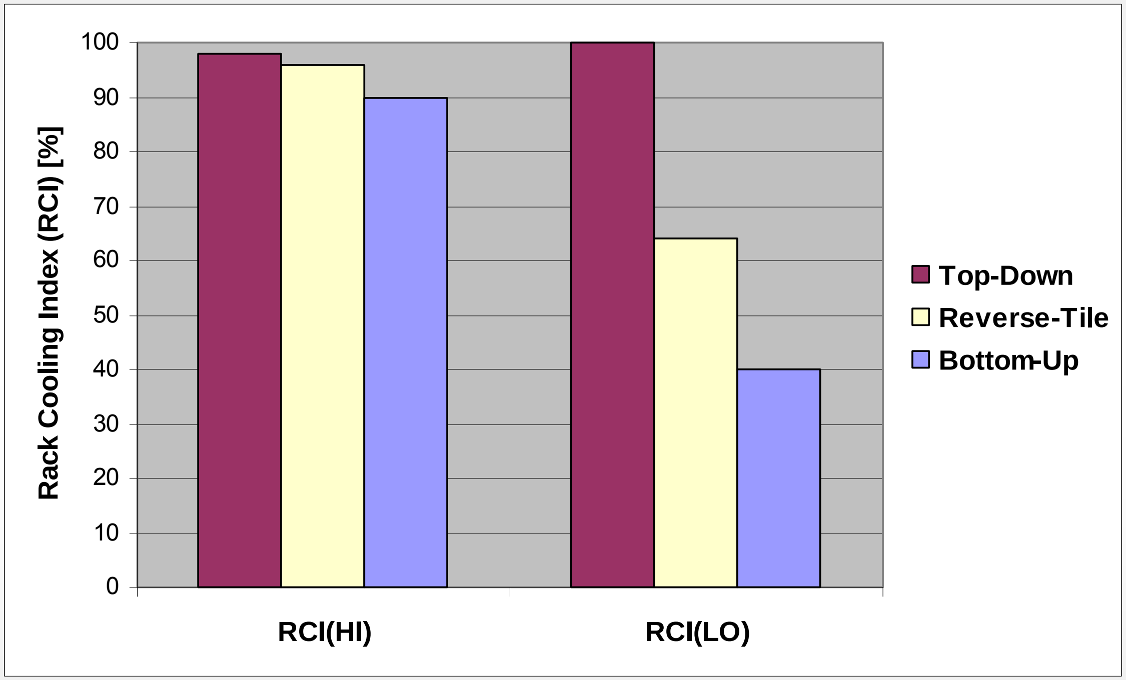
Reverse-Tile

Reference: Herrlin and Belady (2006)

Herrlin, M. K. and Belady, C. 2006. Gravity-Assisted Air Mixing in Data Centers and How it Affects the Rack Cooling Effectiveness. IEEE-ITherm 2006, San Diego, CA, May 30 – June 2, 2006.

**Does gravity contribute to high rack cooling effectiveness?**
**The RCI was used to analyze the cooling systems.**

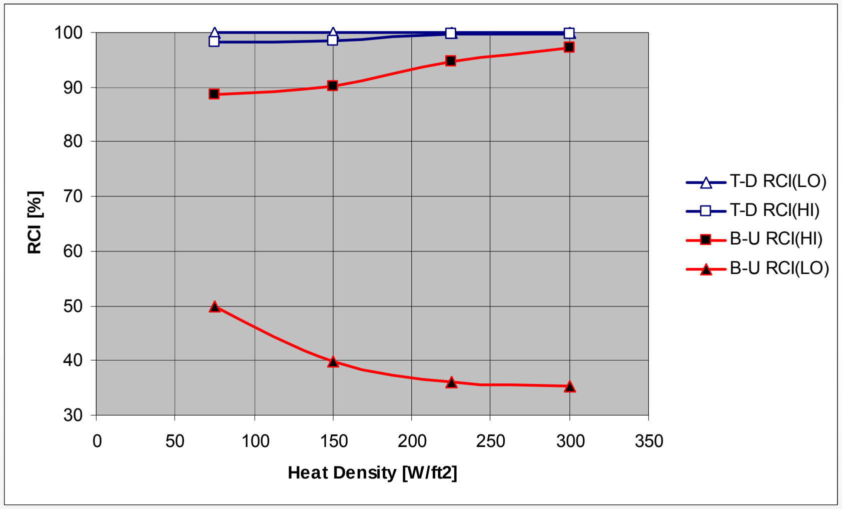
# Over-head vs. Under-floor

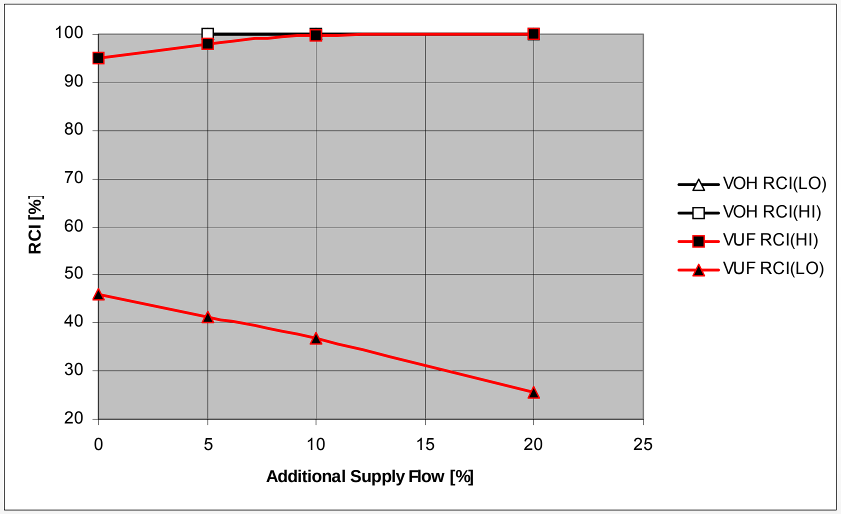



**Clearly, raised-floor cooling (bottom-up) performs the worst…**

# Over-head vs. Under-floor

Further exploring gravity's role in data center cooling




T-D: Top-Down, B-U: Bottom-Up

VOH: Over-Head, VUF: Under-Floor

**Again, raised-floor cooling (bottom-up) underperforms due to *lack of* gravity-assisted air mixing in the cold aisle.**

# Over-head vs. Under-floor

These results are pointing to some significant differences in rack cooling effectiveness (RCI) when gravity-assisted mixing is allowed to thrive (over-head cooling).

This indicates that there are intrinsic performance differences between over-head cooling and under-floor cooling, where over-head cooling has the upper hand.

**This provides an opportunity to develop solutions with both high rack cooling effectiveness *and* high energy efficiency by utilizing the Rack Cooling Index (RCI).**

# Summary

- “Room” temperature vs. intake temperatures
- Equipment intake temperature specifications
- Metric for compliance with temp. specifications (RCI)
- Metric for energy efficiency (Cost Functions)
- Gravity-assisted air mixing
- Over-head cooling in data centers

# THANK YOU !

**Magnus K. Herrlin, Ph.D., CEM**
President
ANCIS Incorporated
mherrlin@ancis.us
www.ancis.us