



## Saving Energy in LBNL's Data Centers: Applying Best Practices

Dale Sartor, PE  
Lawrence Berkeley  
National Laboratory

# Saving Energy in LBNL's Data Centers

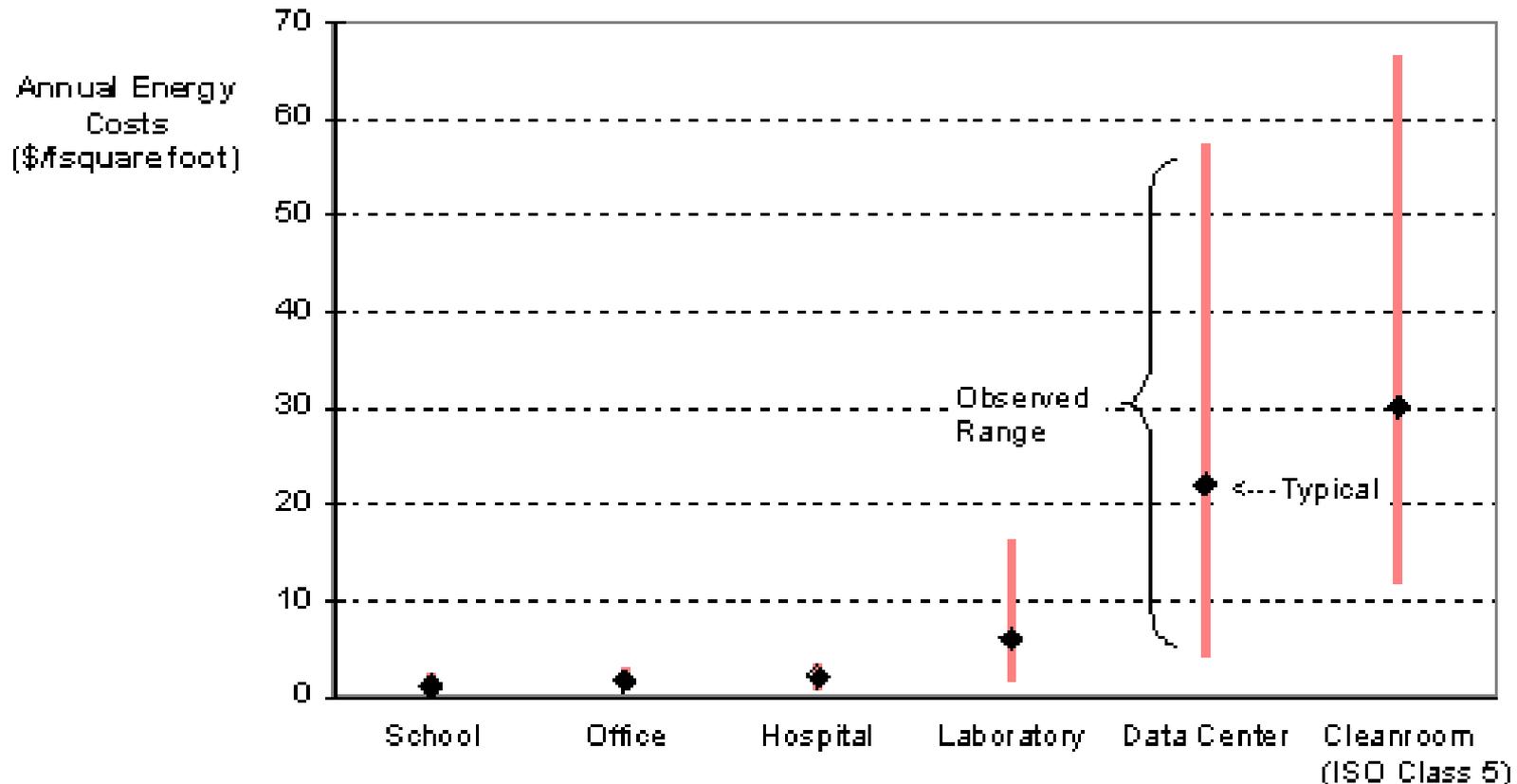
## Applying Best Practices

Dale Sartor, PE  
Applications Team, Building Technologies  
Lawrence Berkeley National Laboratory (LBNL)  
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# High Tech Buildings are Energy Hogs:

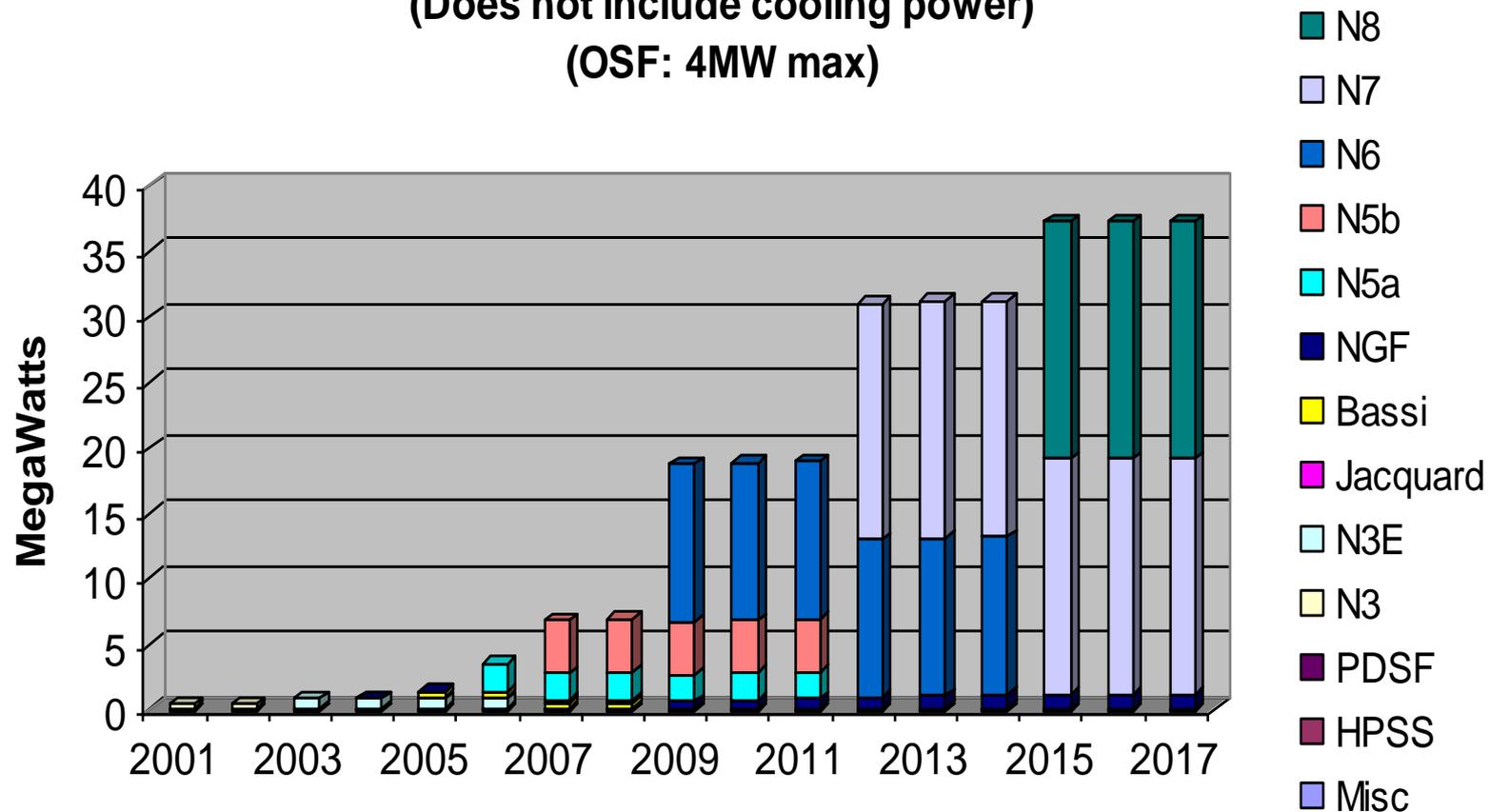
## Comparative Energy Costs High-Tech Facilities vs. Standard Buildings



# LBNL Feels the Pain!



## NERSC Computer Systems Power (Does not include cooling power) (OSF: 4MW max)



## ***Data Center Metrics: PUE***

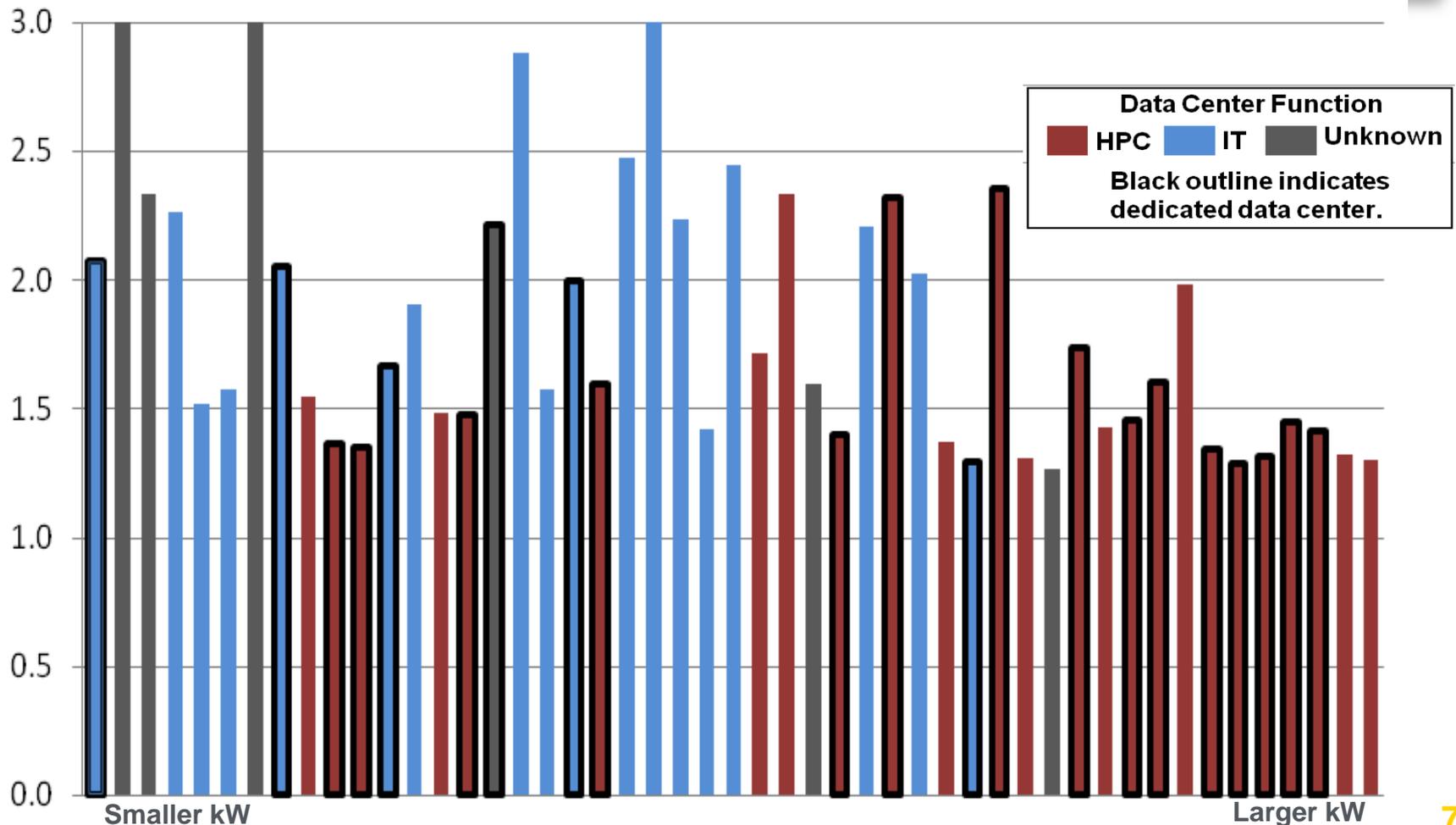
$$PUE = \frac{\text{Total Power}}{\text{IT Power}}$$

Standard	Good	Better
2.0	1.4	1.1

## ***DOE Data Centers***

$$\text{DOE Weighted Average PUE} = \frac{\text{Total DOE Data Center Power}}{\text{DOE Data Center IT Power}} = 1.44$$

## ***PUE of DOE Data Centers***



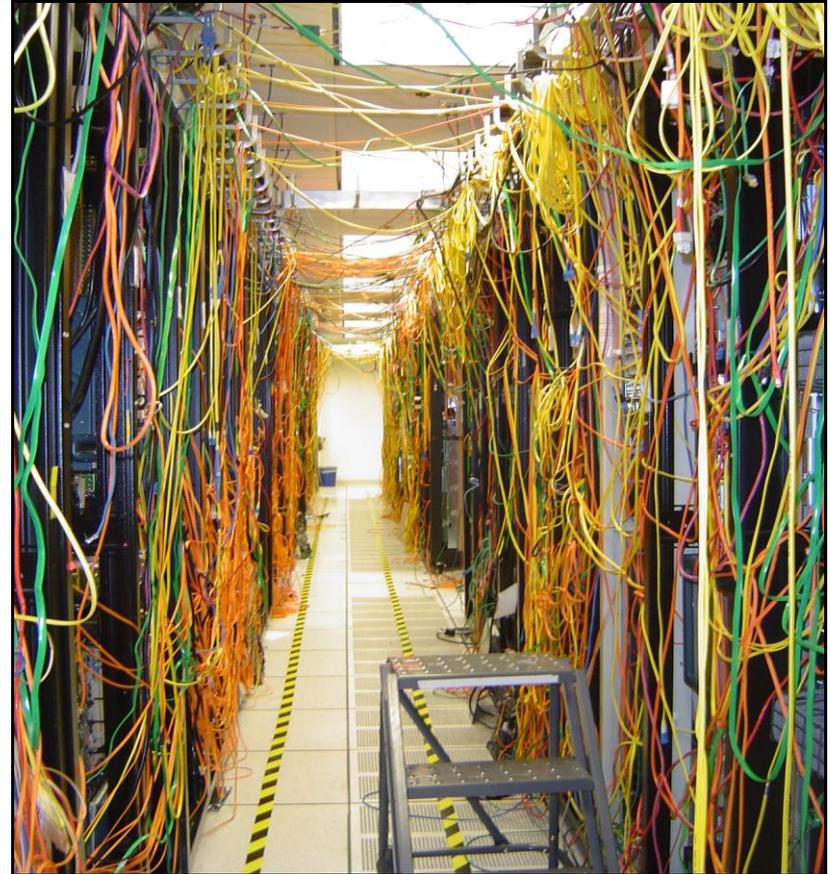
# Potential Benefits of Data Center Energy Efficiency:

- 20-40% savings typical
- Aggressive strategies can yield 50+% savings
- Extend life and capacity of infrastructures



# Best practices based on benchmark results:

- **IT equipment efficiency**
- **Use IT to save energy in IT**
- **Environmental conditions**
- **Air management**
- Right-sizing
- Central plant optimization
- Efficient air handling
- **Liquid cooling**
- **Free cooling**
- **Humidity control**
- **Improve power chain**
- On-site generation
- **Design and M&O processes**



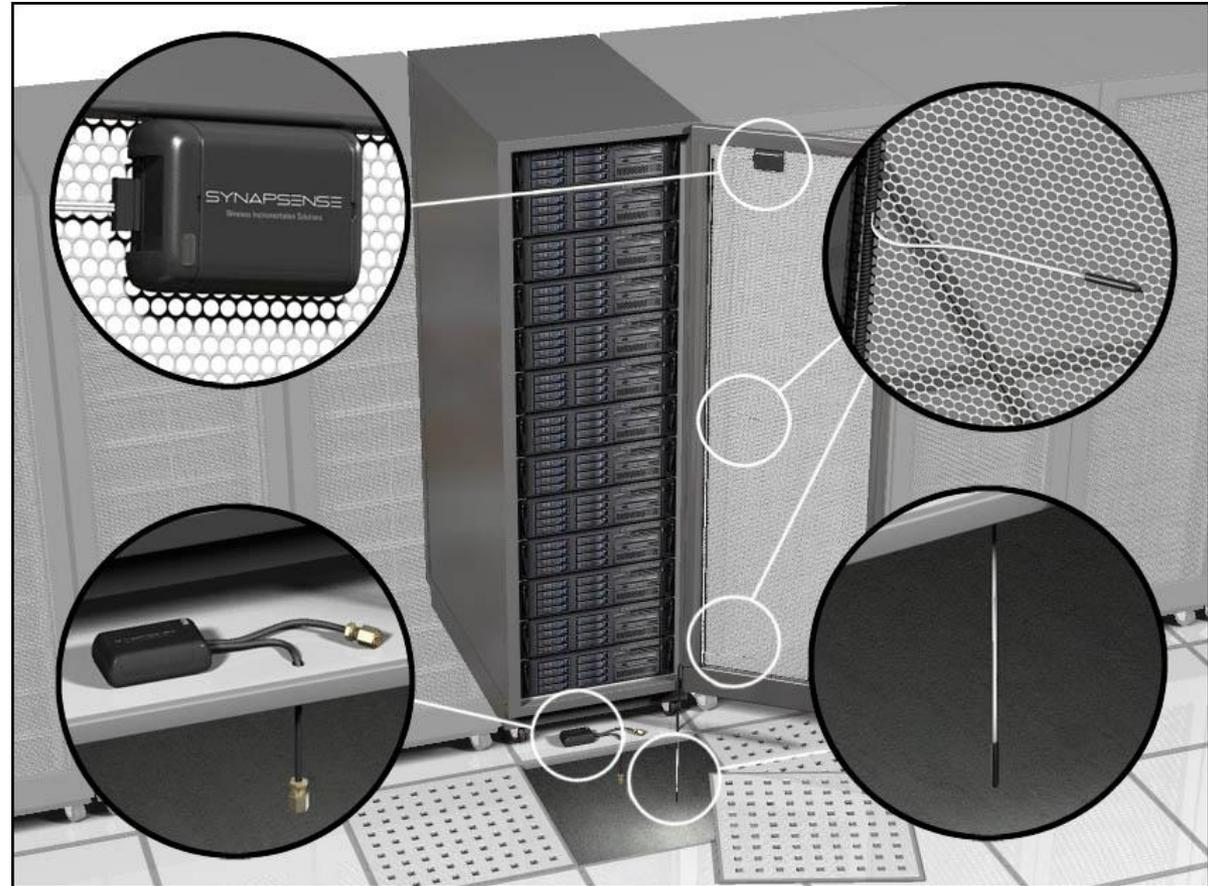
# IT equipment load can be controlled:

*Computations per Watt is improving, but computation demand is increasing even faster so overall energy is increasing. Lifetime electrical cost will soon exceed cost of IT equipment.*

- **Consolidation**
- **Server efficiency**
  - Flops per watt
  - Efficient power supplies
- **Software efficiency (Virtualization, MAID, etc.)**
- **Power management**
  - Low power modes
- **Reconsider redundant power supplies**
- **Reducing IT load has a multiplier effect**
  - Equivalent savings +/- in infrastructure

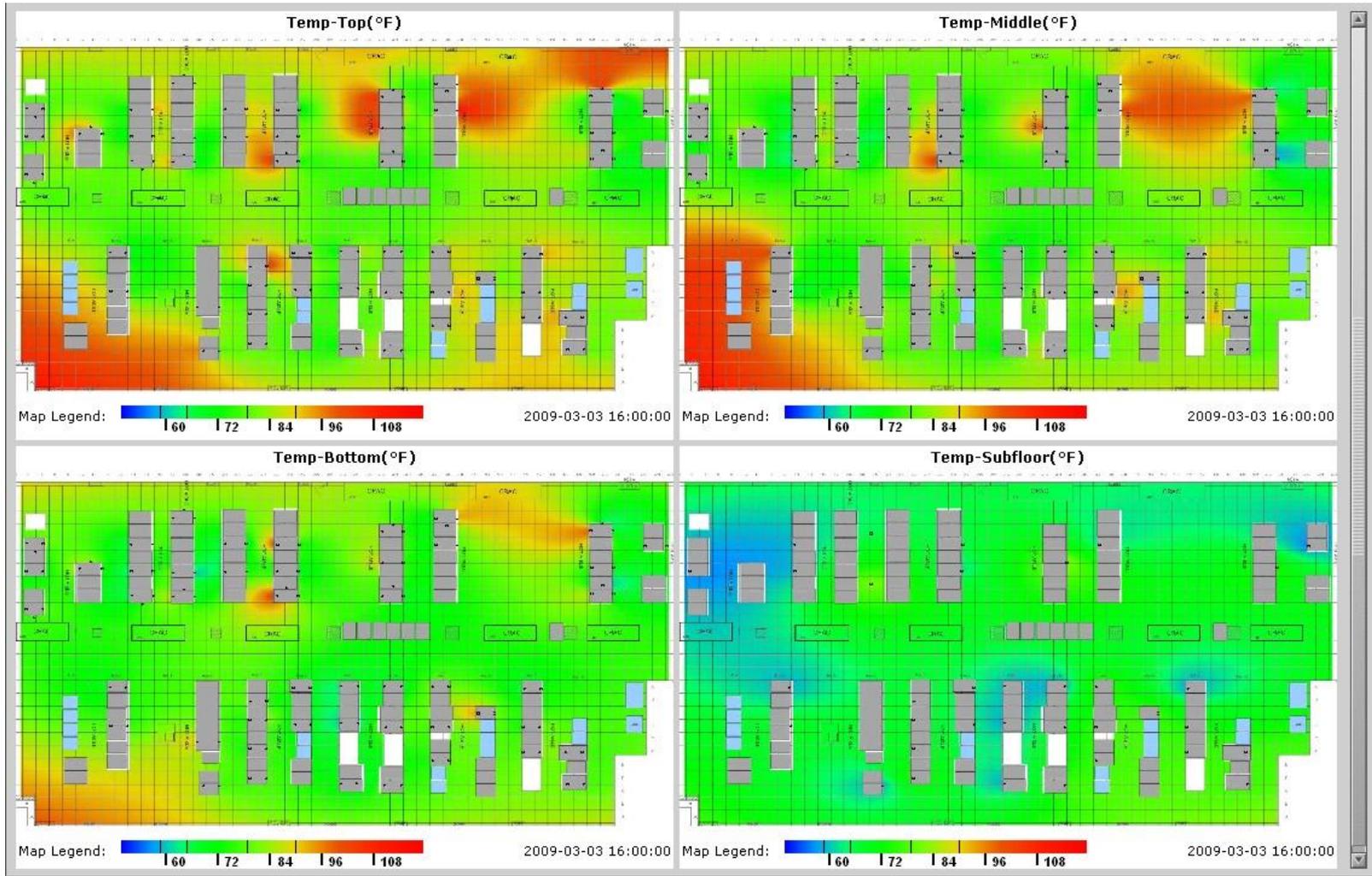
- Most operators lack visibility into their data center environment
- We can't manage what we don't measure
- Provide the same level of monitoring and visualization of the physical space as we have for the IT environment
- Measure and track performance metrics
- Spot problems before they result in high energy cost or down time

- 700 point SynapSense System
  - Temperature, humidity, under-floor pressure, current



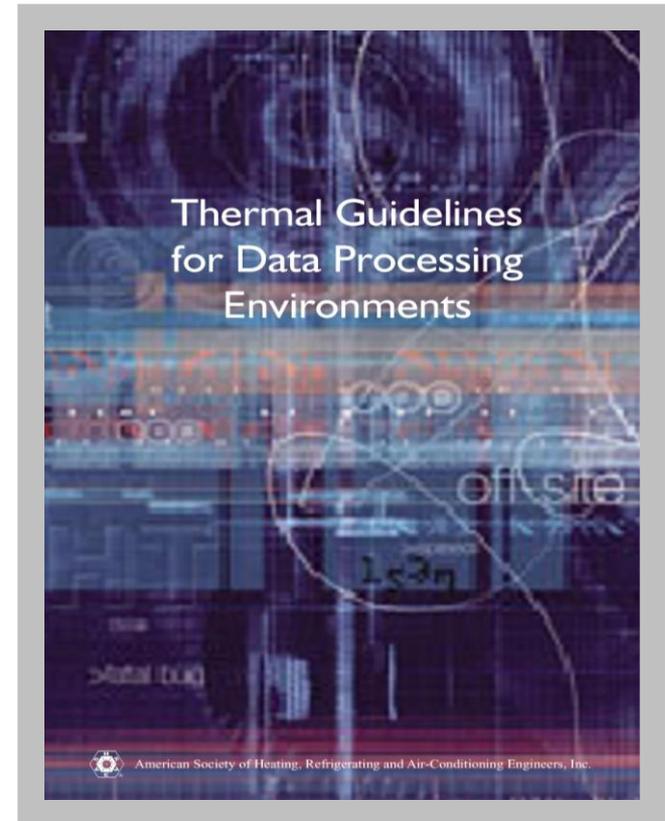
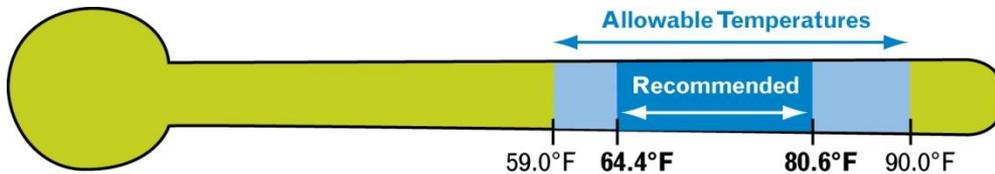
source: SynapSense

# Visualization getting much better



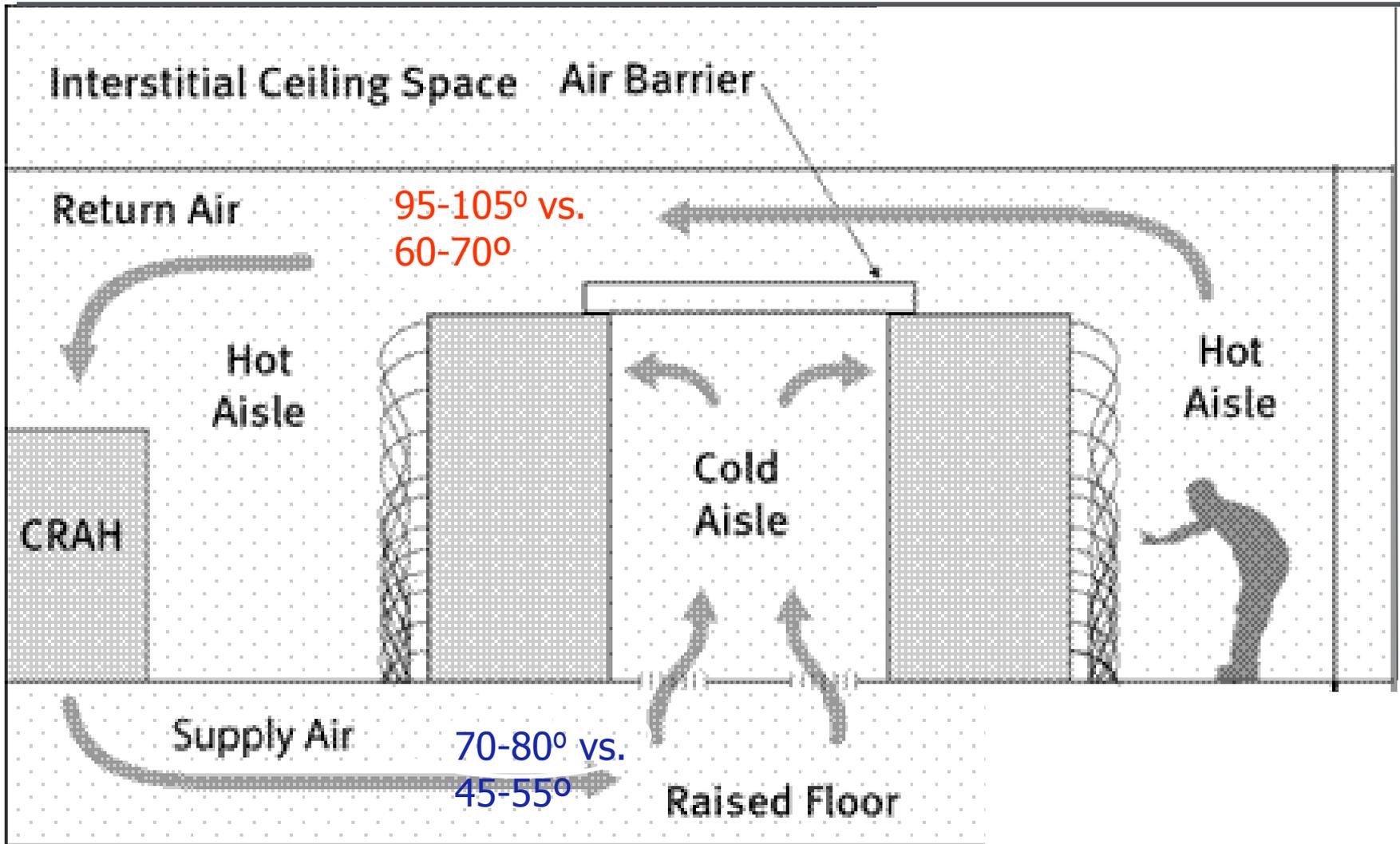
SynapSense™

- Use ASHRAE Recommended and Allowable ranges of temperature and humidity



- Typically, much more air is circulated through computer room air conditioners than is required
- Air mixing and short circuiting leads to:
  - Low supply temperature
  - Low Delta T
- Improve isolation of hot and cold “aisles”
  - Reduce fan energy
  - Improve air-conditioning efficiency
  - Increase cooling capacity

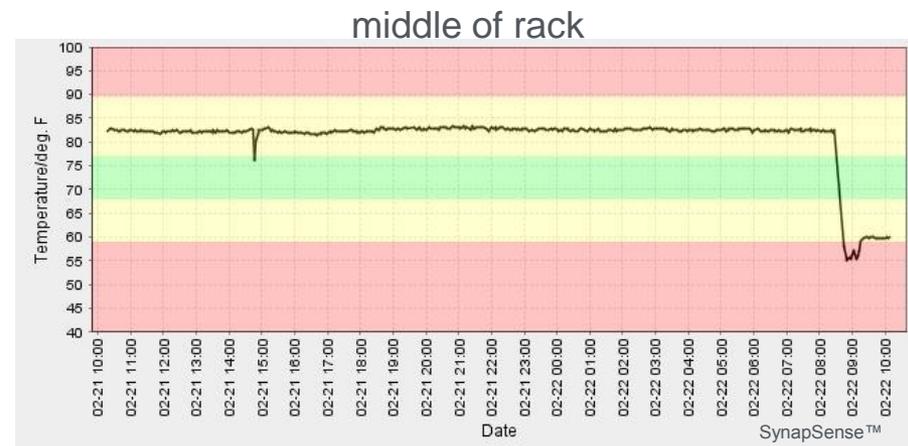
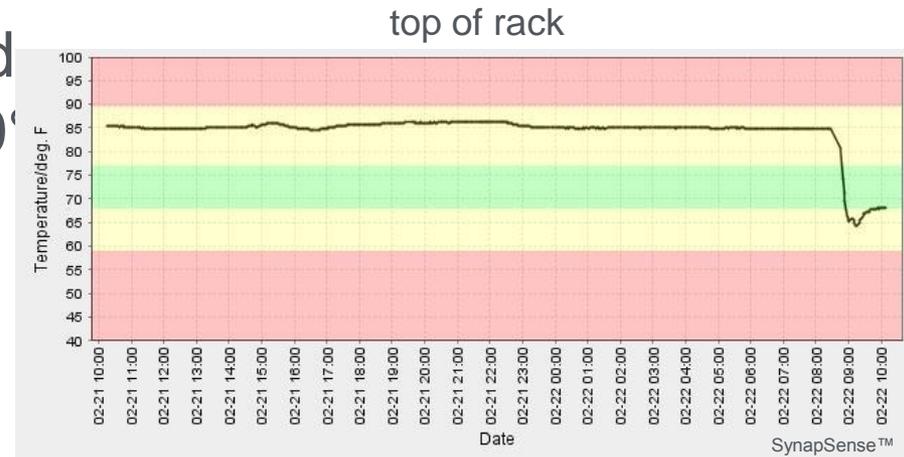
# Best Scenario— Isolate Cold and Hot



- Performed CFD
- Deployed wireless monitoring system
- Identified opportunities for improvement
  - Enforce hot aisle/cold aisle arrangement
  - Use blanking panels
  - Improve airflow and under floor pressure by tuning floor tiles
  - Reduce mixing and short circuits
  - Convert overhead plenum to hot-air return
  - Extend CRAC intakes into overhead
  - Add air curtains to improve isolation

# Results: Blanking Panels

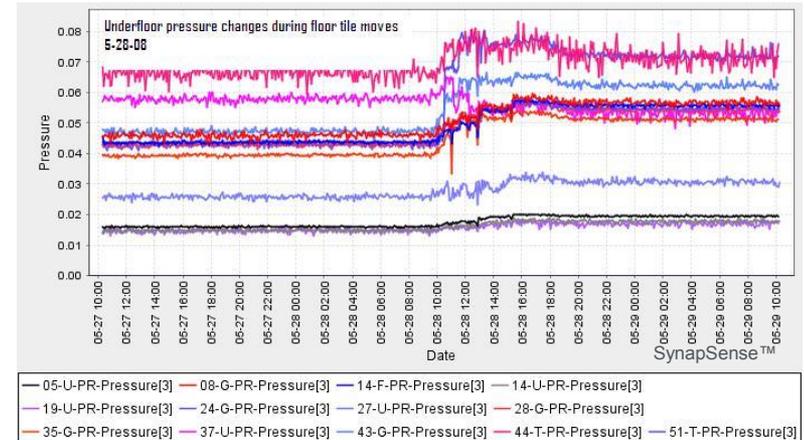
- One 12” blanking panel added and temperature dropped ~20°
- Impact of other best practices confirmed
  - Eliminate leaks in floor
  - Improve air management



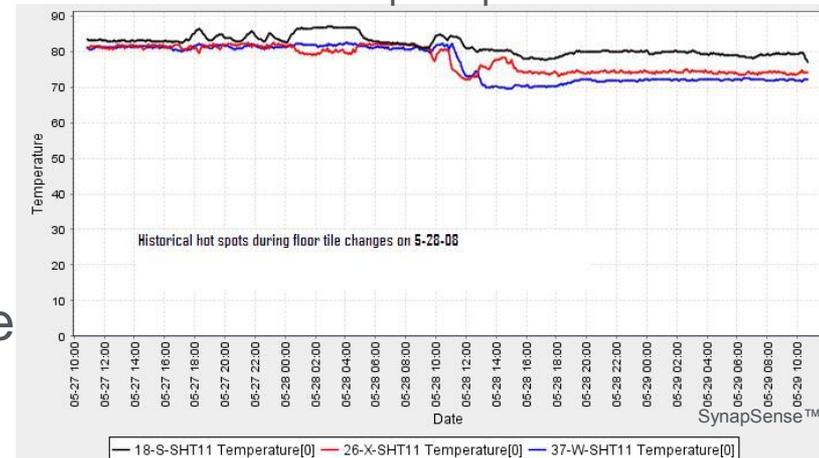


- Too many permeable floor tiles
- if airflow is optimized
  - under-floor pressure  $\uparrow$
  - rack-top temperatures  $\downarrow$
  - data center capacity increases
- Measurement and visualization assist tuning process

### under-floor pressures



### rack-top temperatures



# Improve Air Management:

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



Before



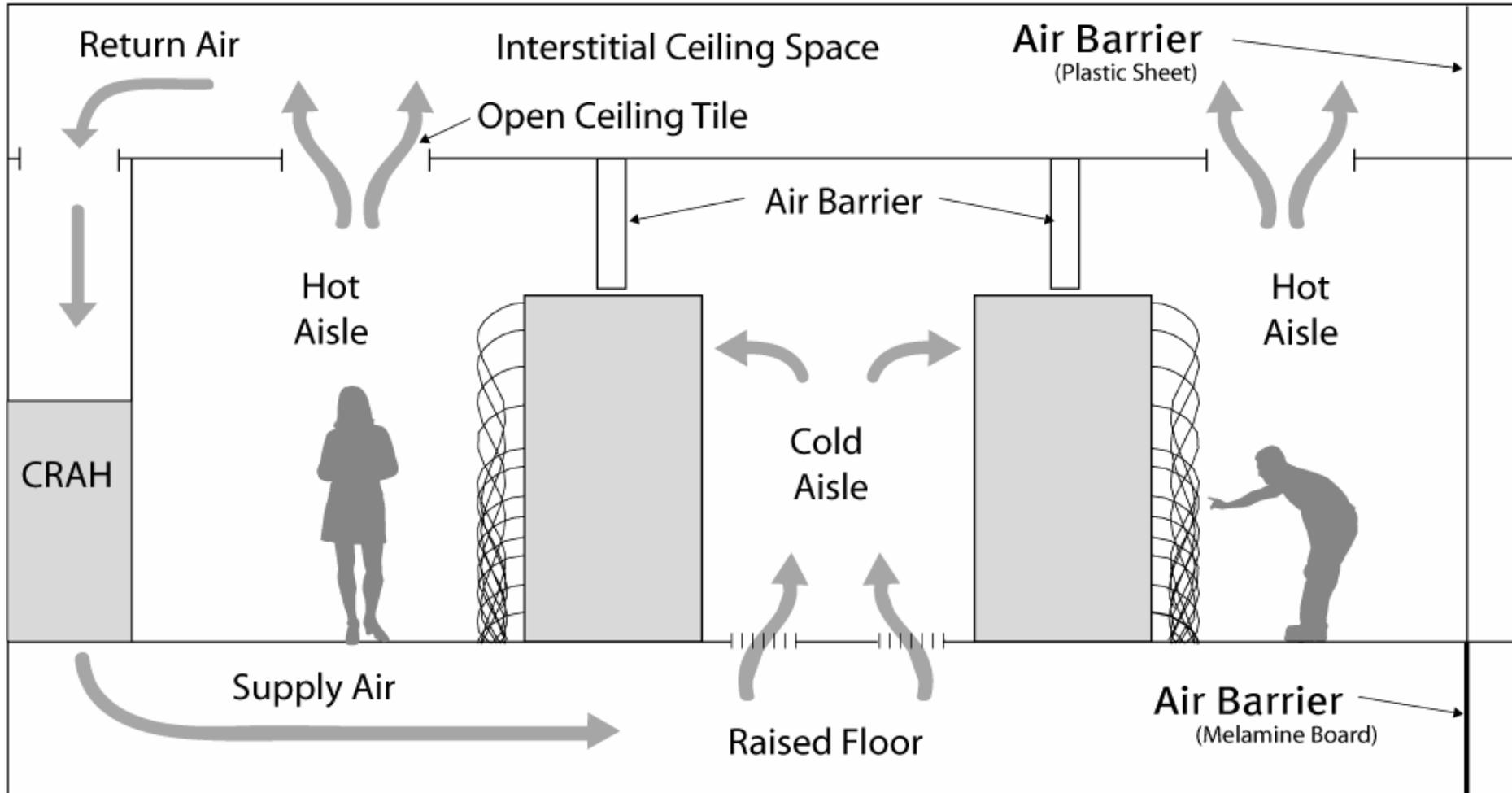
After



# Adding Air Curtains for Hot/Cold Isolation



# Improve Air Management:

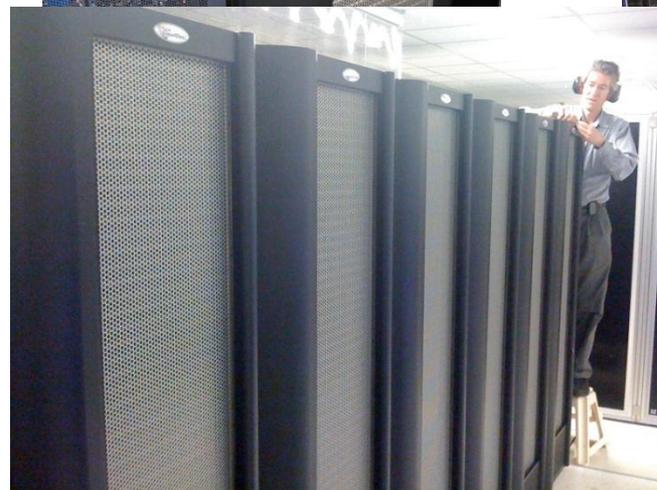


# Use Free Cooling:

- Water-side Economizers
  - No contamination question
  - Can be in series with chiller
- Outside-Air Economizers
  - Can be very effective (24/7 load)
  - Must consider humidity
- Let's get rid of chillers in data centers



- Infrastructure installed in 2008 for liquid cooling in 50B-1275
- Cooled with tower only or chiller assisted
  - Both options significantly better than existing liquid cooled (DX) CRAC units



# Improve Humidity Control:

- Eliminate inadvertent dehumidification
  - Computer load is sensible only
- Use ASHRAE allowable RH and temperature
  - Many manufacturers allow even wider humidity range
- Eliminate equipment fighting
  - Coordinate controls

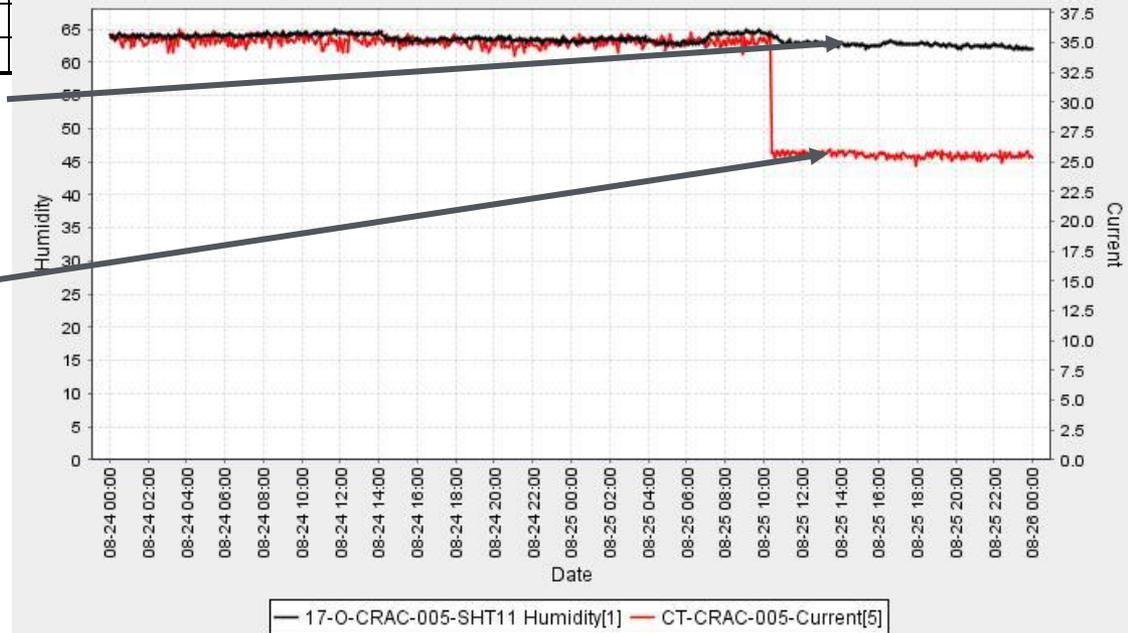
# The Cost of Unnecessary Humidification

	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			
Avg	79.2	31.7	46.4	68.8			

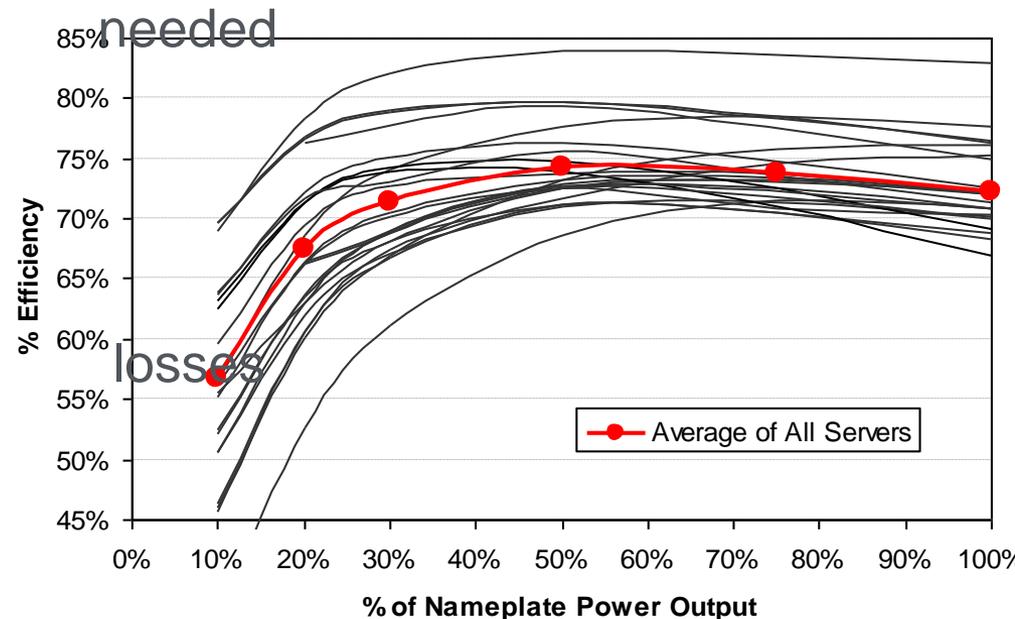


Humidity down 3%

CRAC power down 28%



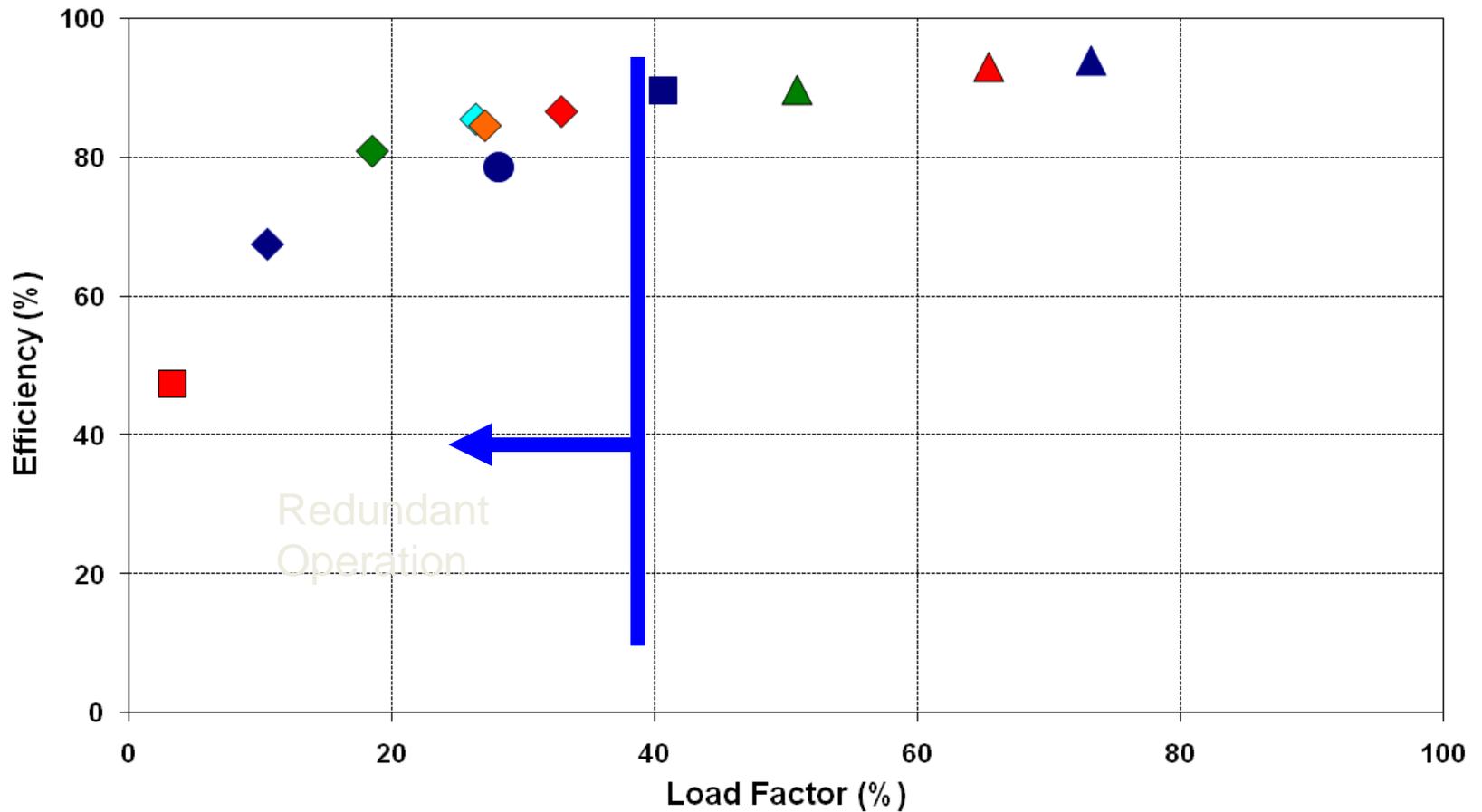
- Increase distribution voltage
  - NERSC going to 480 volts to the racks
- Improve equipment power supplies
  - Avoid redundancy unless needed
- Improve UPS
  - LBNL uses minimal UPS
  - Selected to minimize losses



- Understand what redundancy costs – is it worth it?
- Different strategies have different energy penalties (e.g.  $2N$  vs.  $N+1$ )
- Redundancy in electrical distribution puts you down the efficiency curve
- LBNL minimizes use of redundant power supplies and size of UPS

# Measured UPS Efficiency

## UPS Efficiency





[http://www1.eere.energy.gov/femp/program/data\\_center.html](http://www1.eere.energy.gov/femp/program/data_center.html)



<http://hightech.lbl.gov/datacenters.html>



[http://www.energystar.gov/index.cfm?c=prod\\_development.server\\_efficiency](http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency)



<http://www1.eere.energy.gov/industry/datacenters/>

## Contact Information:

Dale Sartor, P.E.  
Lawrence Berkeley National Laboratory  
Applications Team  
MS 90-3111  
University of California  
Berkeley, CA 94720

[DA\\_Sartor@LBL.gov](mailto:DA_Sartor@LBL.gov)  
(510) 486-5988  
<http://Ateam.LBL.gov>

