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A River of Energy Solutions

Saving Energy in Data Centers
Developing and Applying Best Practices

Dale Sartor, PE,

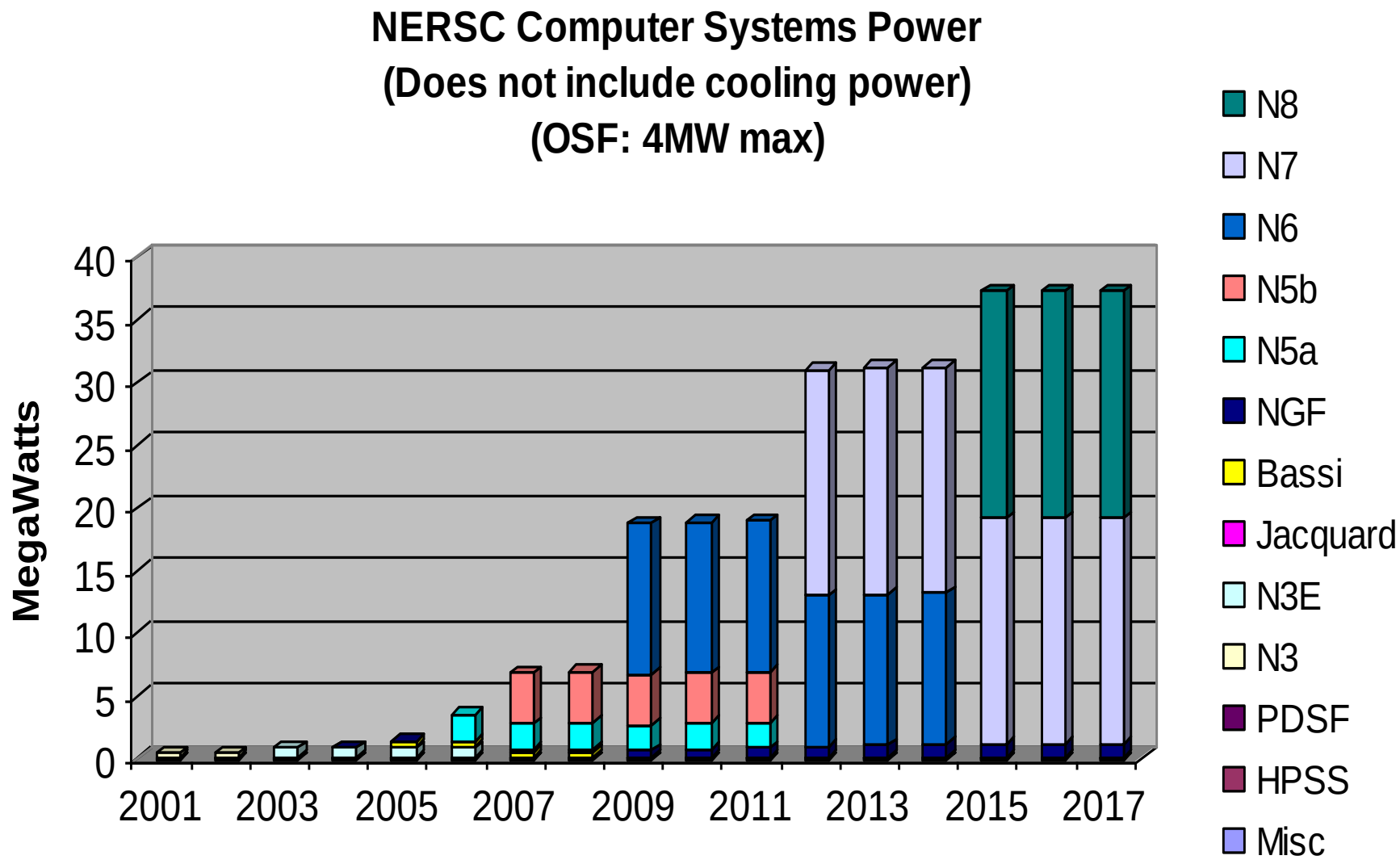
Lawrence Berkeley National Laboratory

Data Center Energy

- Data centers are energy intensive facilities
  - 10 to 100+ times more energy intensive than other commercial space
  - 1.5% of US Electricity consumption in 2006
  - Projected to double in next 5 years
  - Power and cooling constraints in existing facilities
- Data centers are not exempt from federal efficiency requirements

LBNL Feels the Pain!

LBNL Super Computer Systems Power

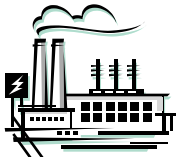


Data Center Energy Efficiency

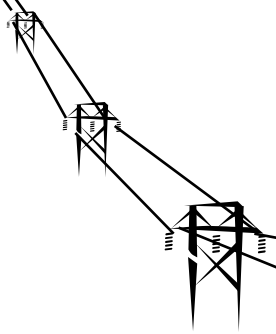
(Energy Efficiency = Useful computation / Total Source Energy)

Typical Data Center Energy End Use = 15% (or less)

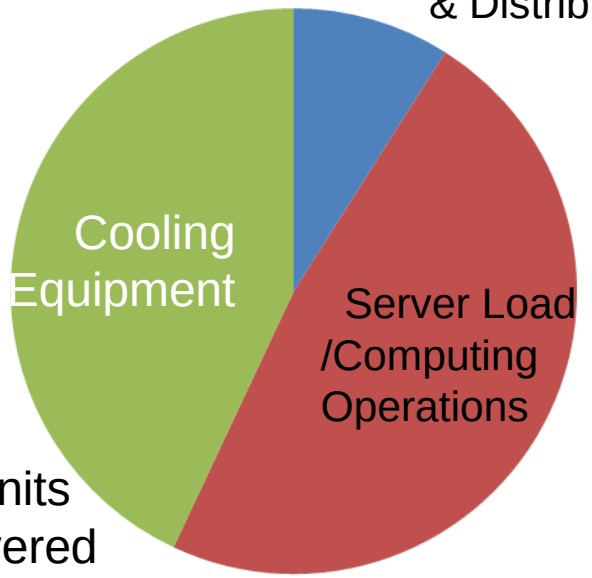
100 Units
Source
Energy



35 Units
Power Generation



33 Units
Delivered



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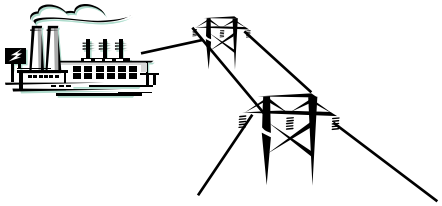
Energy Efficiency Opportunities



- Server innovation
- Virtualization
- High efficiency power supplies
- Load management

- Better air management
- Move to liquid cooling
- Optimized chilled-water plants
- Use of free cooling
- Heat recovery

Power Conversion & Distribution

Server Load/ Computing Operations

Cooling Equipment

- High voltage distribution
- High efficiency UPS systems
- Efficient redundancy strategies
- Use of DC power

On-site Generation

- On-site generation Including fuel cells and renewable sources
- CHP applications (Waste heat for cooling)

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Potential Benefits of Data Center Energy Efficiency

- 20-40% savings typical
- Aggressive strategies can yield 50+% savings
- Extend life and capacity of infrastructures
- But is mine good or bad?

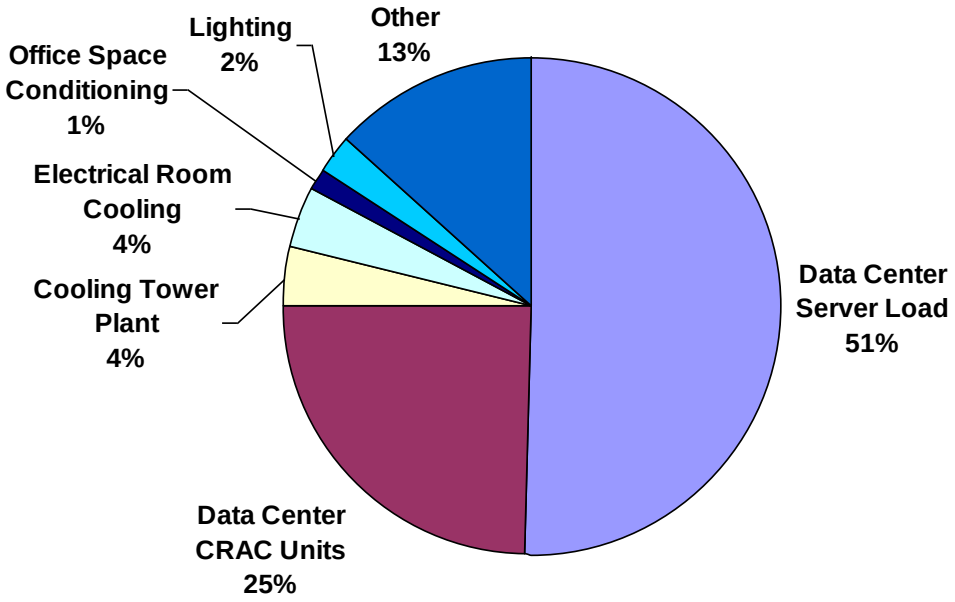
Benchmark Energy Performance

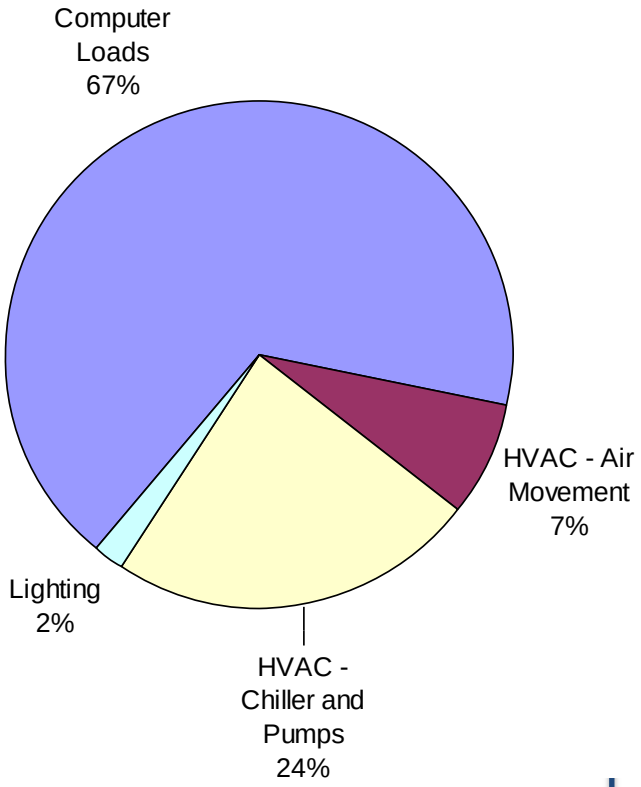
- Compare to peers
  - Wide variation
- Identify best practices
- Track performance
  - Can't manage what isn't measured

Your Mileage Will Vary

The relative percentages of the energy actually doing computing varied considerably.

Data Center 1

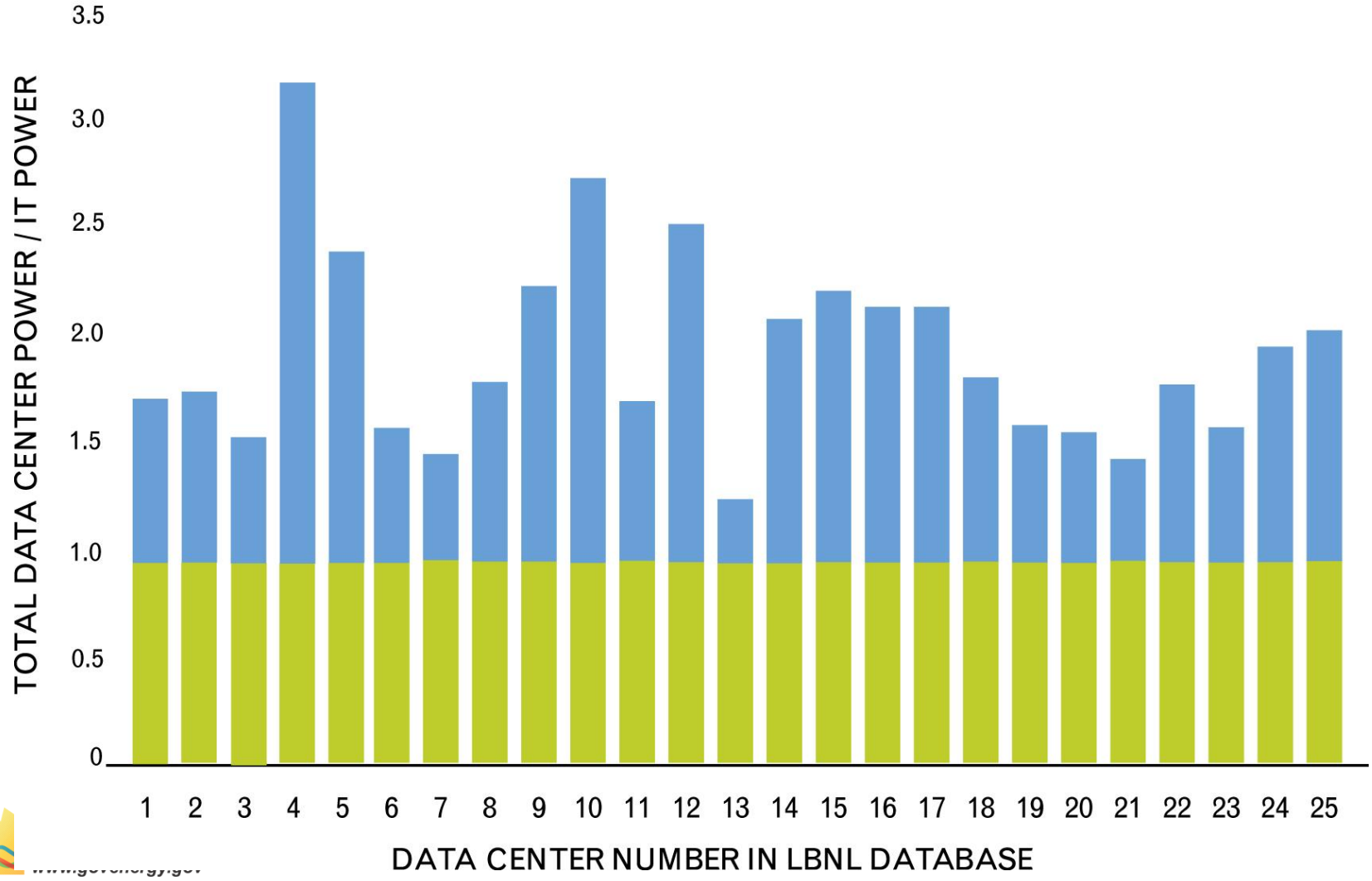




Data Center 2

High Level Metric

Power Utilization Effectiveness (PUE) = Total Power/IT Power



You Can't Manage What You Don't Measure

The private sector has a better handle on data center efficiency metrics

What Do They Know*?	Private sector*	Public sector
PUE?	82%	23%
Average load?	94%	31%
Average server power density?	95%	29%

% of respondents who can provide data on these metrics for their organizations.
MeriTalk Study released June 2011

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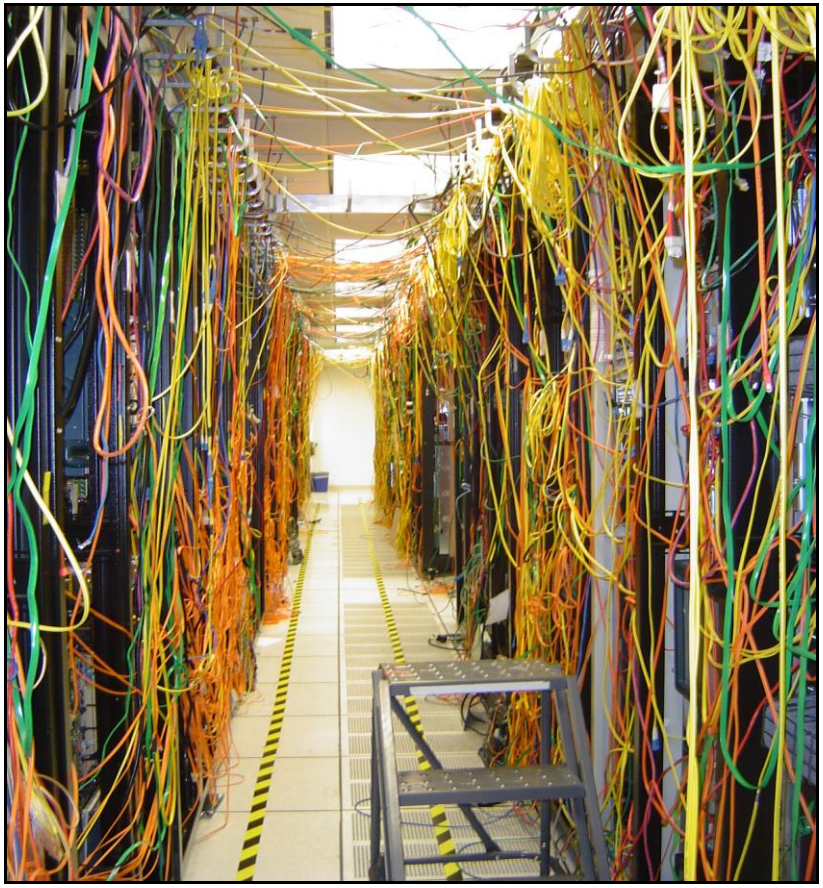
Best Practices Based on Benchmarking Results

- 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



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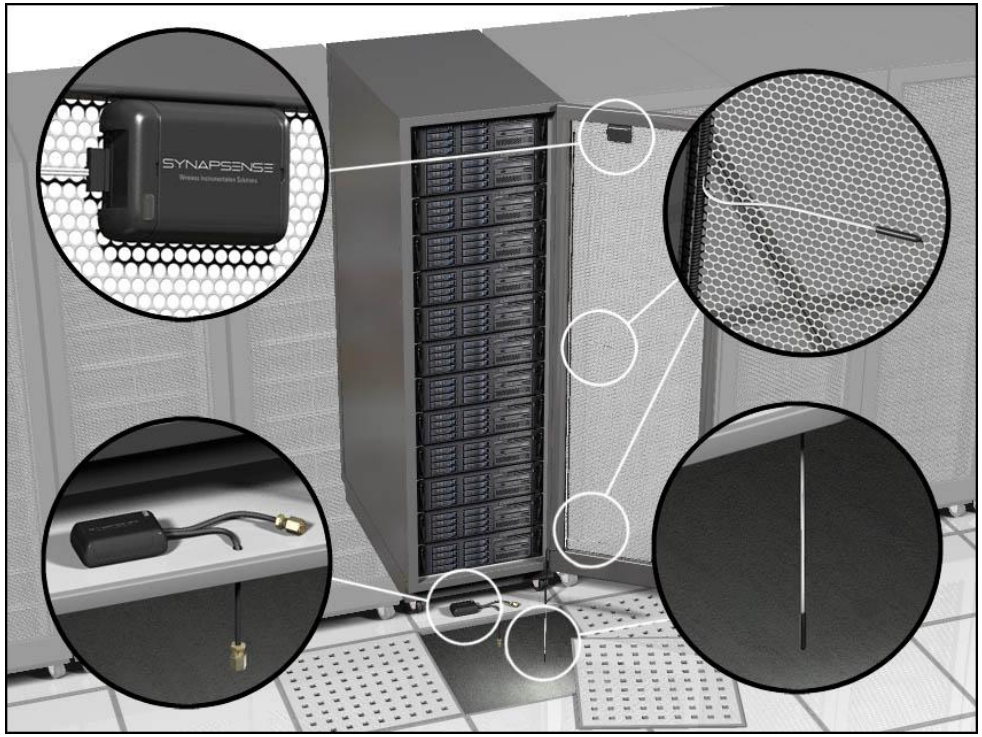
Applying Best Practices at LBNL

- Partnership between CIO, CS, and energy efficiency researchers, facilities
- Existing data centers relatively efficient
  - NERSC: PUE = 1.3 (1.4), takes advantage of central plant
  - 50B-1275: PUE = 1.45 (1.65), tower cooled CRACs and rear doors
- Increased efficiency frees up needed “capacity”
- Leveraging data centers as test beds to create an impact beyond Berkeley Lab
- Working with vendors to develop new products and strategies

Using IT to Save Energy in IT

- Operators lack visibility into data center environment
- Provide same level of monitoring and visualization of the physical space as we have for the IT environment
- Measure and track performance
- Spot problems early
- 700 point SynapSense system
  - Temperature, humidity, under-floor pressure, current

LBNL Wireless Monitoring System



source: SynapSense

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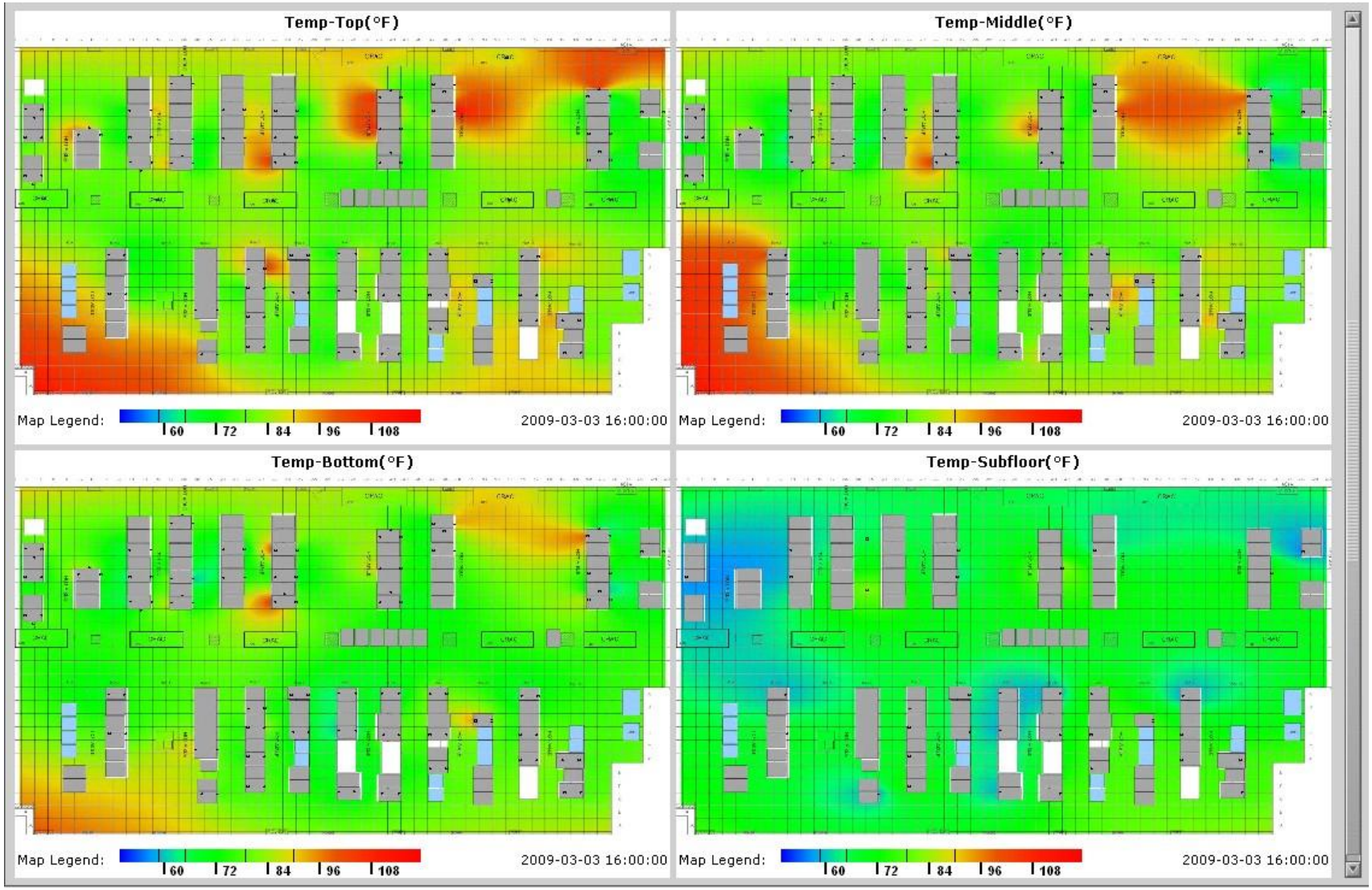
Visualization getting much better



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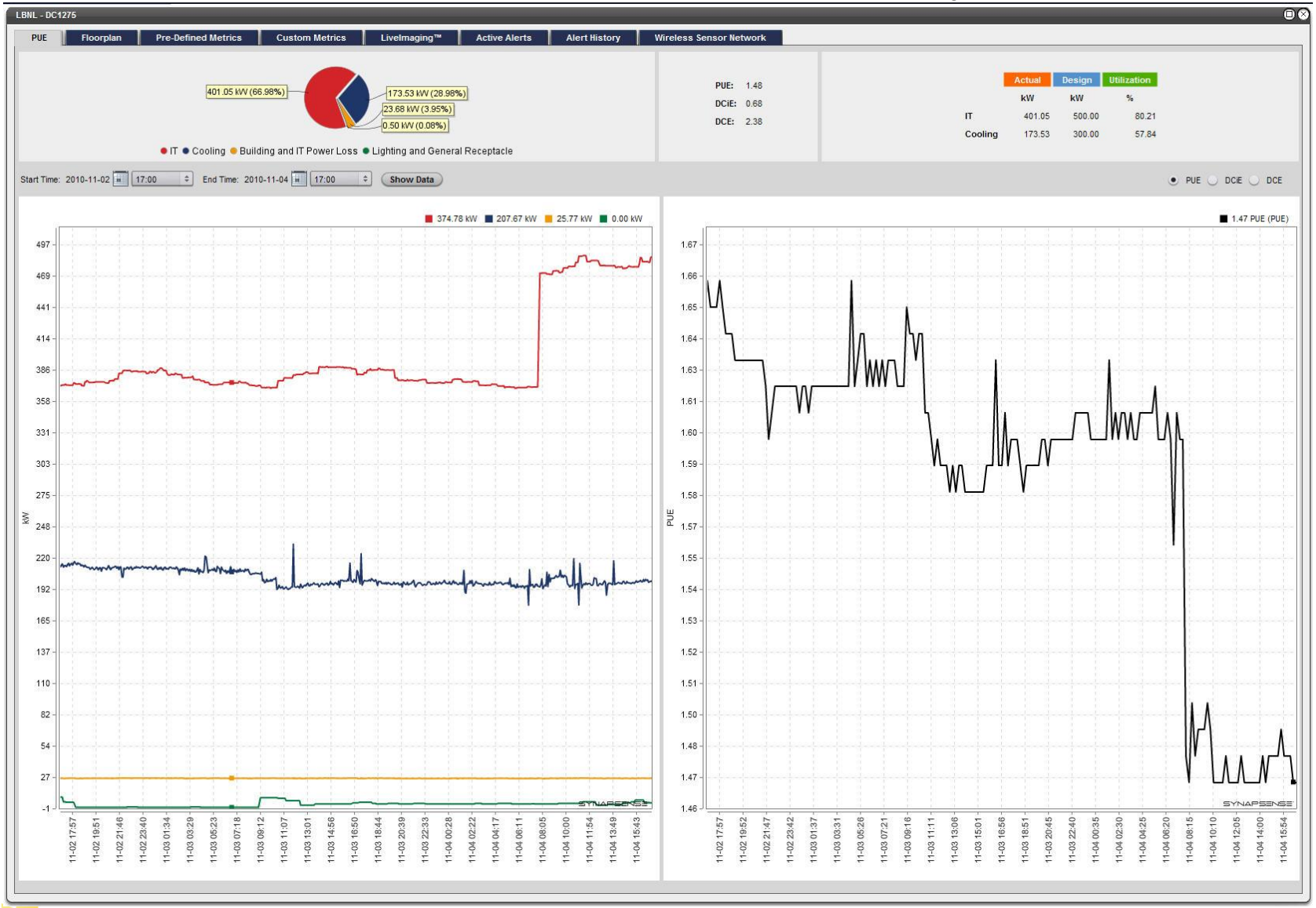
SynapSense™

Real-time PUE Display



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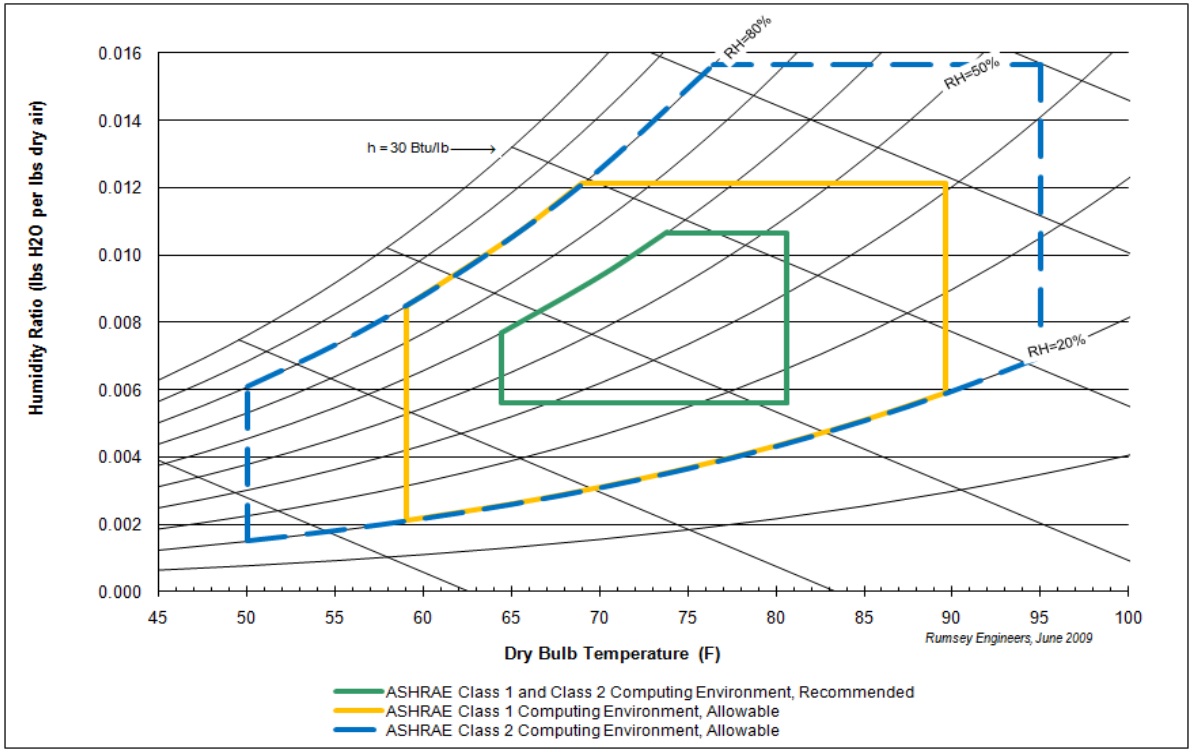
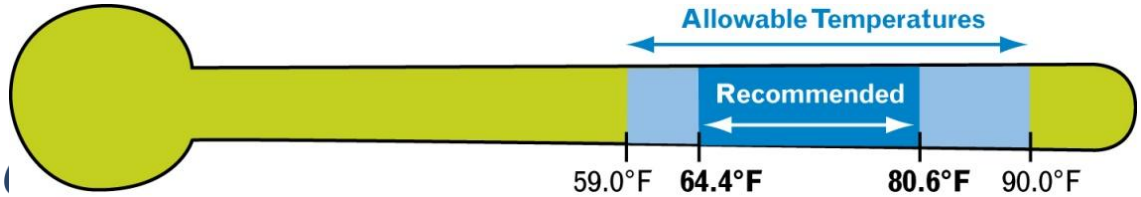
SynapSense™

Environmental Conditions

- Use ASHRAE Recommended and Allowable ranges of temperature and humidity





Air Management: The Early Days

It was cold but hot spots were everywhere

Fans were used to redirect air

High flow tiles reduced air pressure

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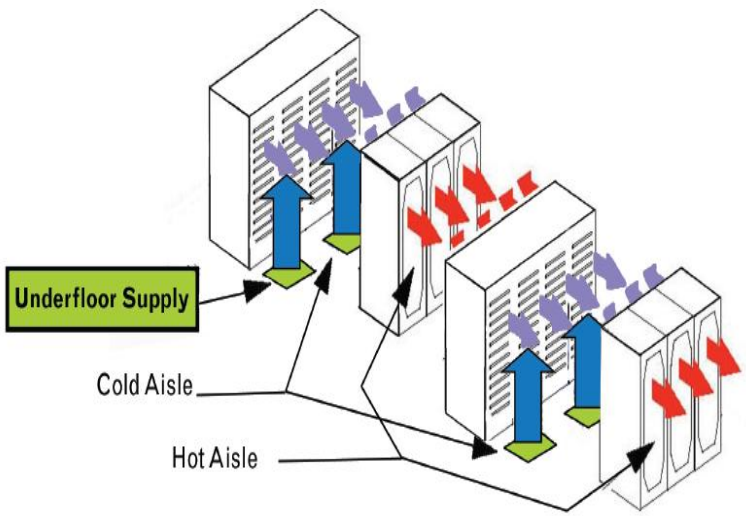
Improve Air Management

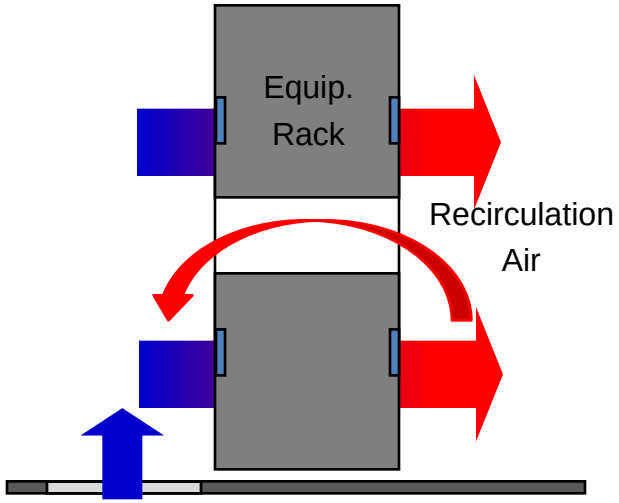
- Typically, more air circulated than required
- Air mixing and short circuiting leads to:
  - Low supply temperature
  - Low Delta T
- Use hot and cold aisles
- Improve isolation of hot and cold aisles
  - Reduce fan energy
  - Improve air-conditioning efficiency
  - Increase cooling capacity



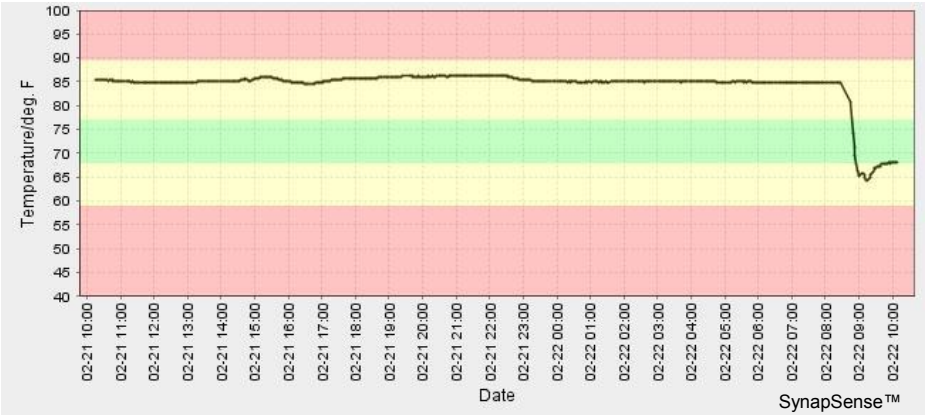
Hot aisle / cold aisle configuration decreases mixing of intake & exhaust air, promoting efficiency.

Results: Blanking Panels

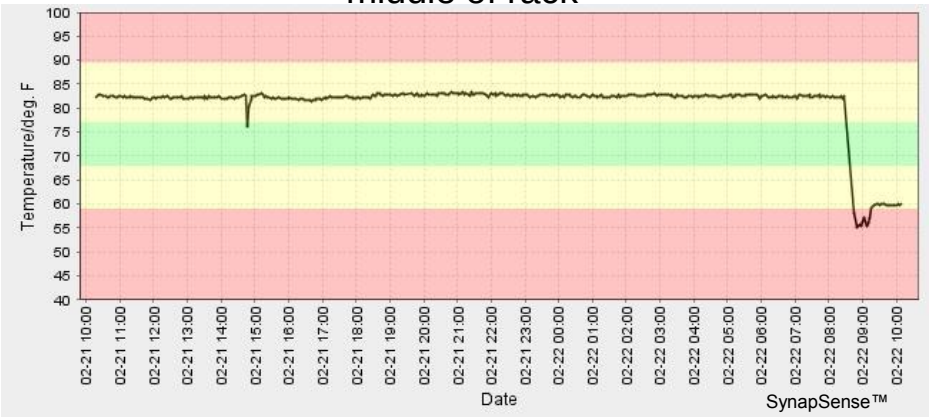
One 12” blanking panel added Temperature dropped ~20°



top of rack



middle of rack



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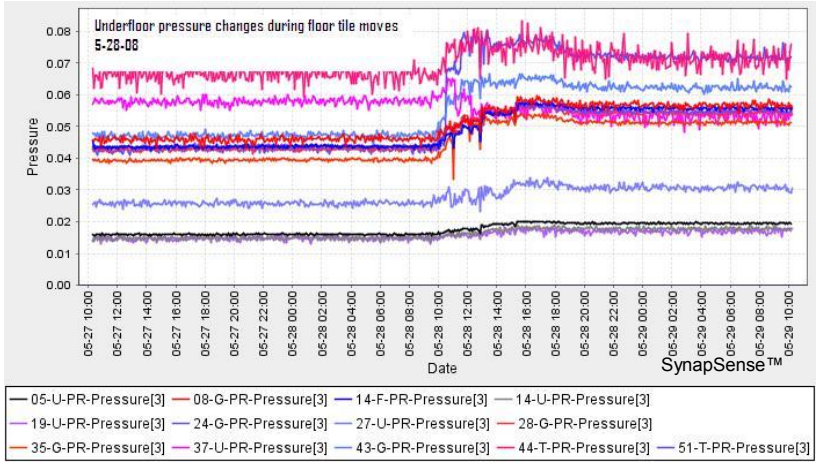
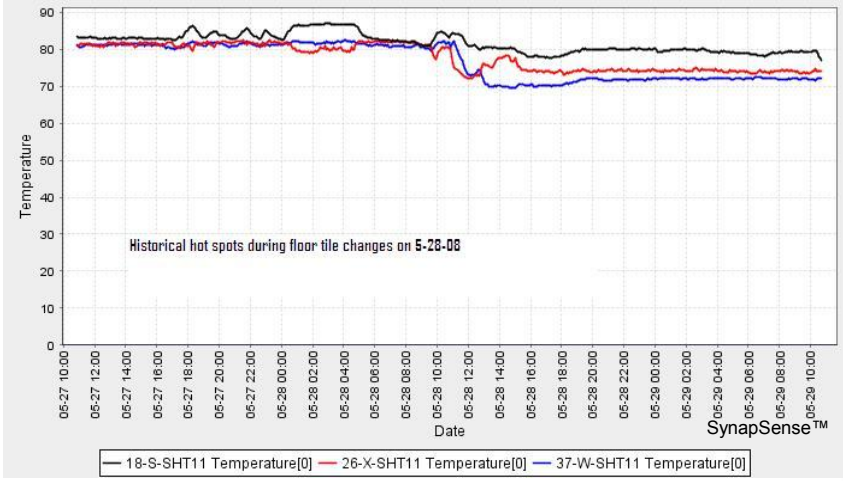
Results: Tune Floor Tiles

under-floor pressures



rack-top temperatures



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

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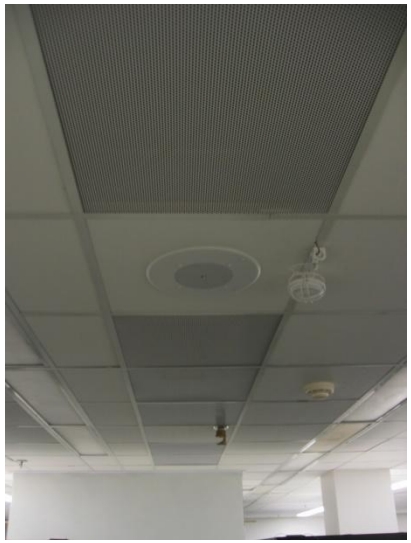
Enclose Return Air

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

Before

After



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Adding Air Curtains for Hot/Cold Isolation

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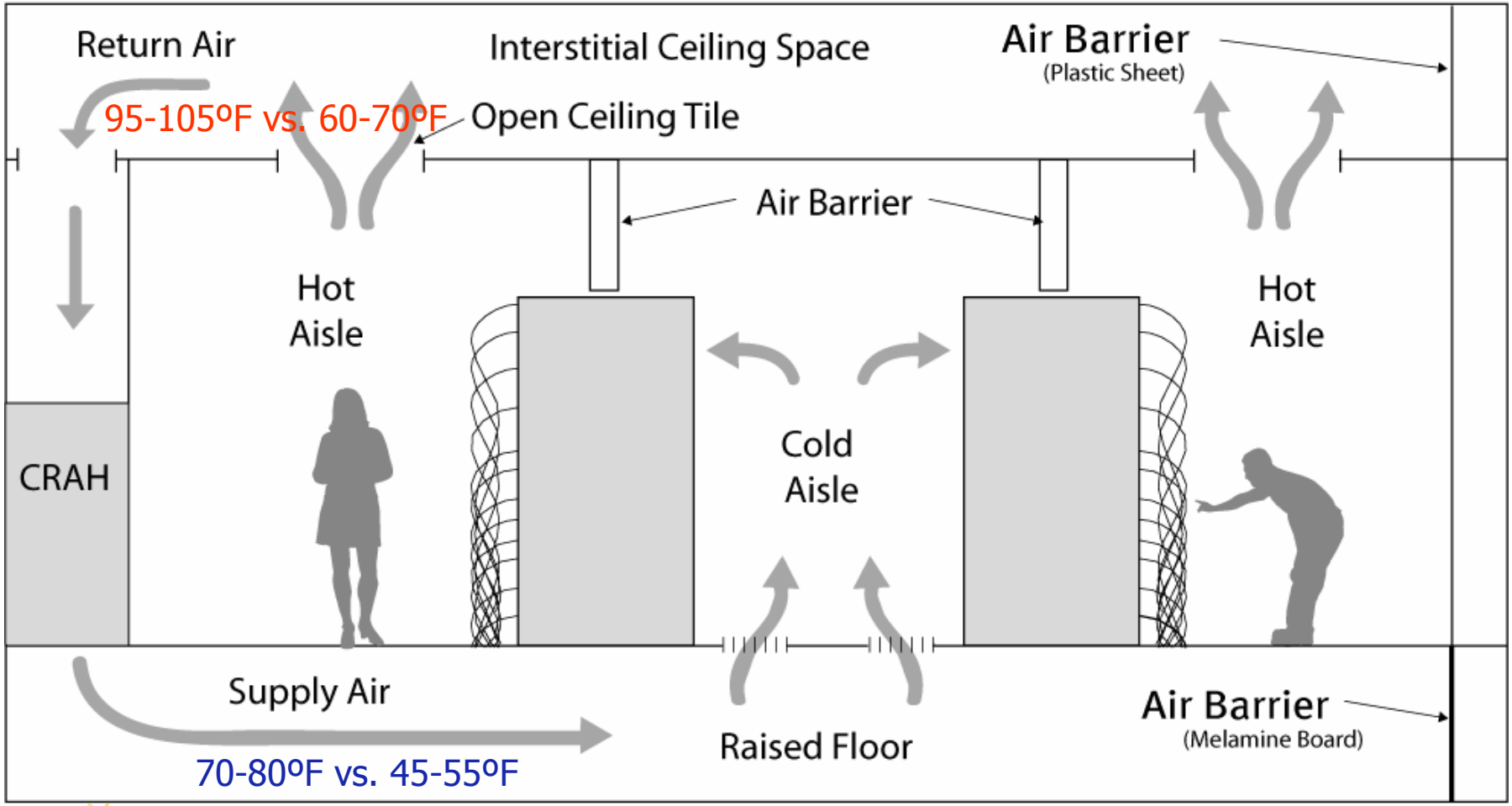
Improved Air Management:

Isolate Cold and Hot Aisles



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Use Free Cooling:

- Outside-Air Economizers
- Water-side Economizers
- Let's get rid of chillers in data centers

Free Cooling – Liquid Based

- Liquid is more efficient than air for heat transfer
- Cooling with tower only or chiller assisted
  - Both options better than existing DX CRAC units

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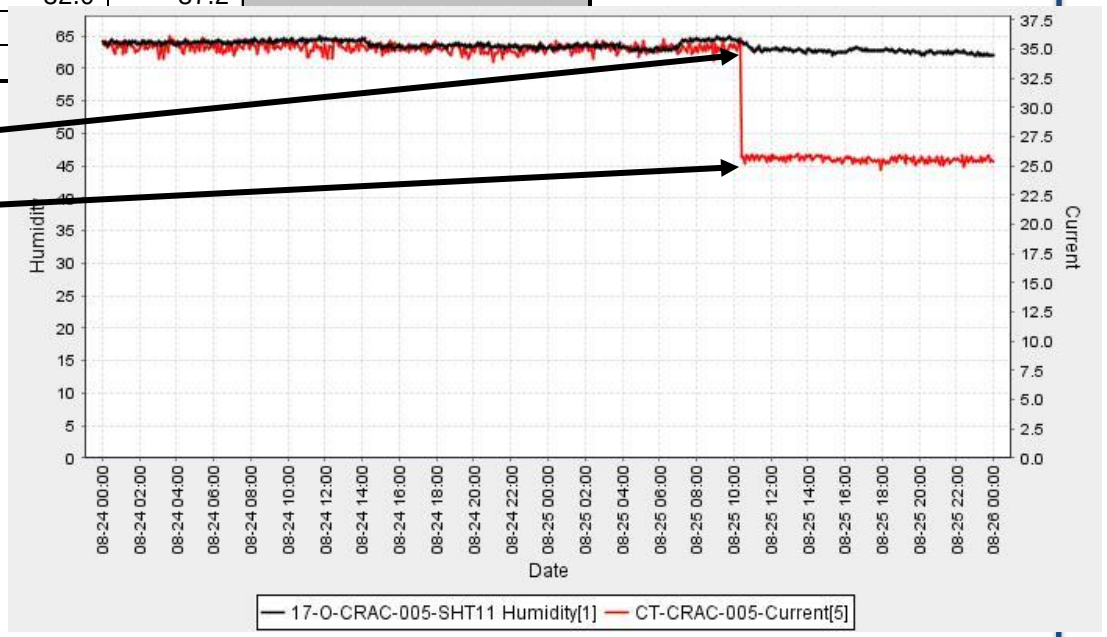
Improve Humidity Control

	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%



- Eliminate inadvertent dehumidification
- Use ASHRAE allowable RH and temperature
  - Eliminate equipment fighting

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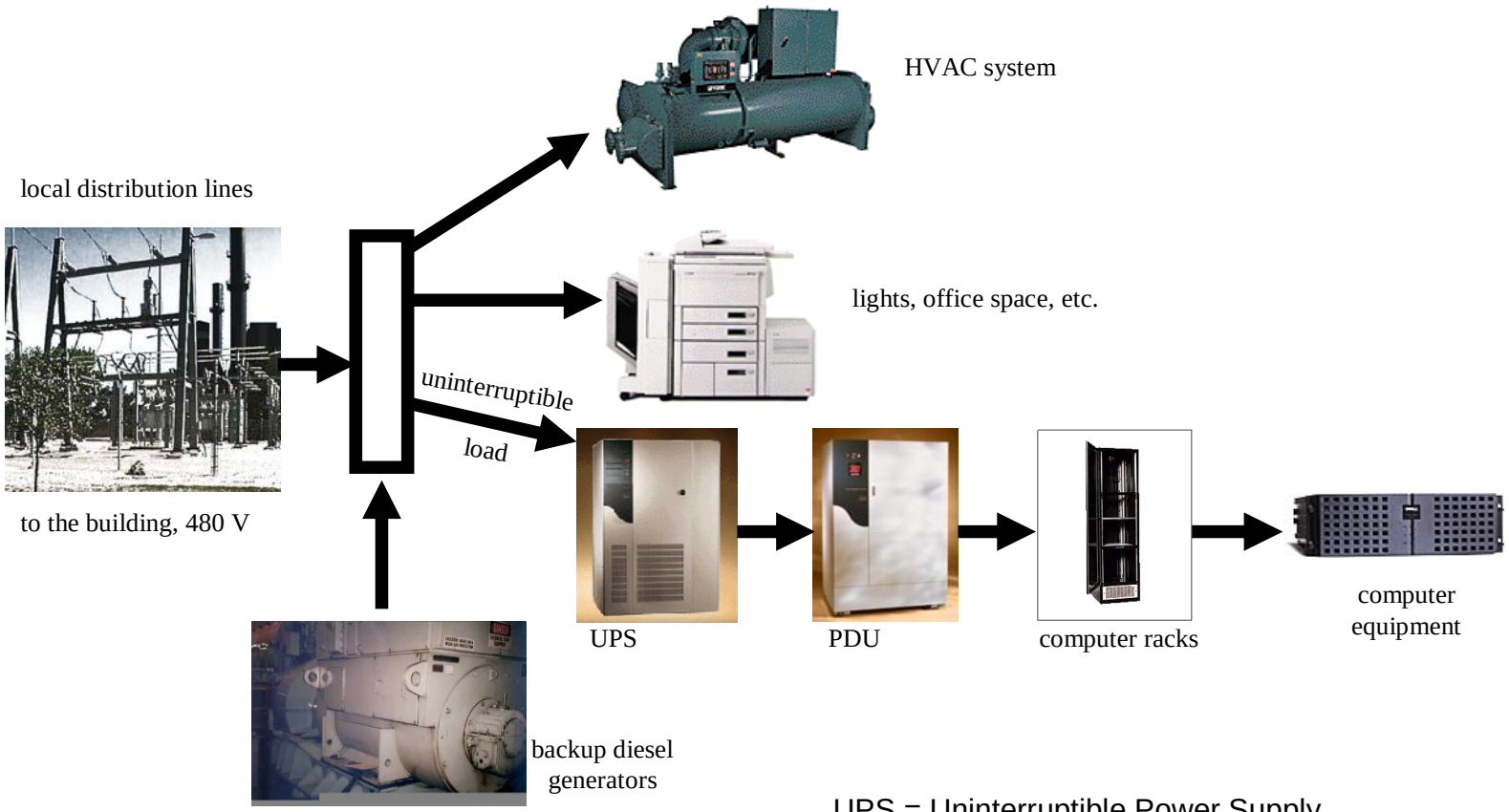
Power Chain Conversions Waste Energy

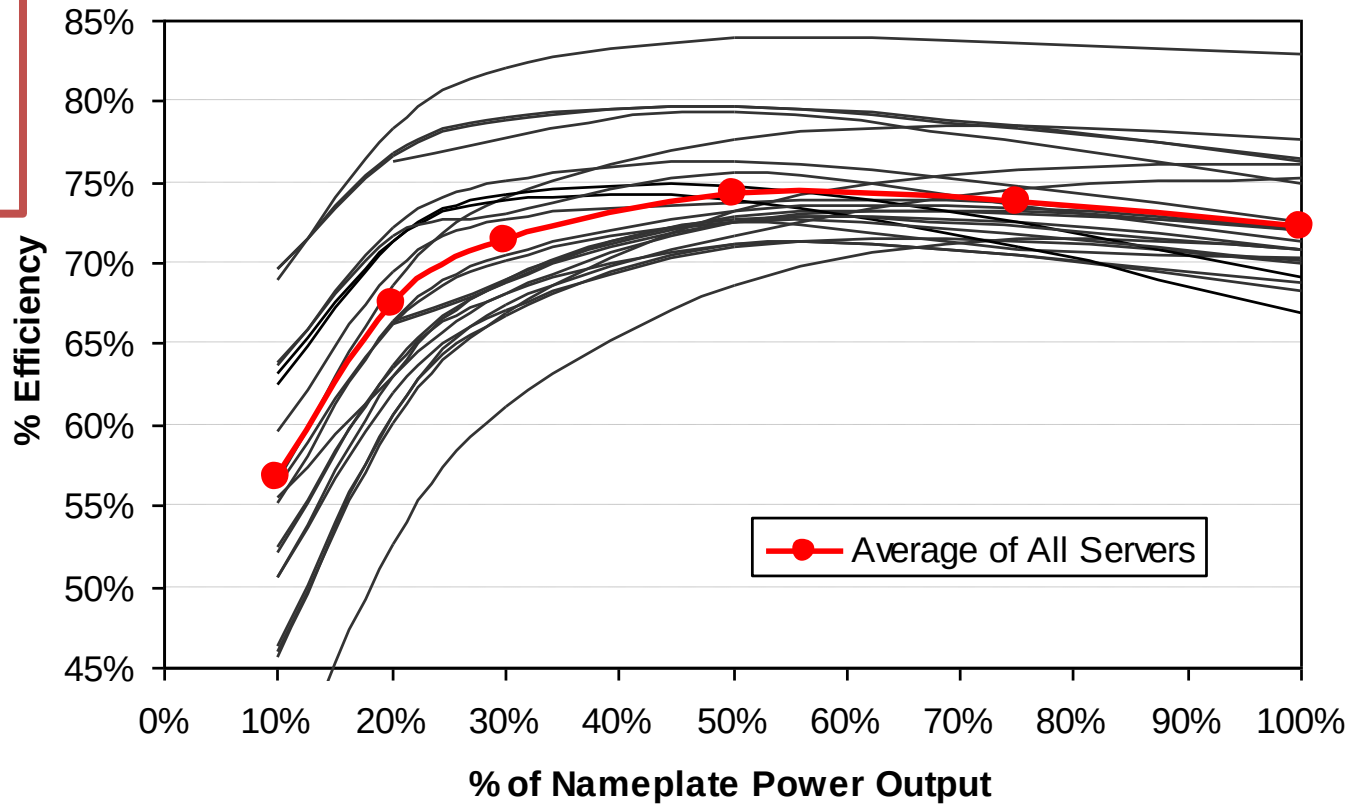
Electricity Flows in Data Centers



UPS = Uninterruptible Power Supply

PDU = Power Distribution Unit;

Select and Configure Power Supplies for Greater Efficiency



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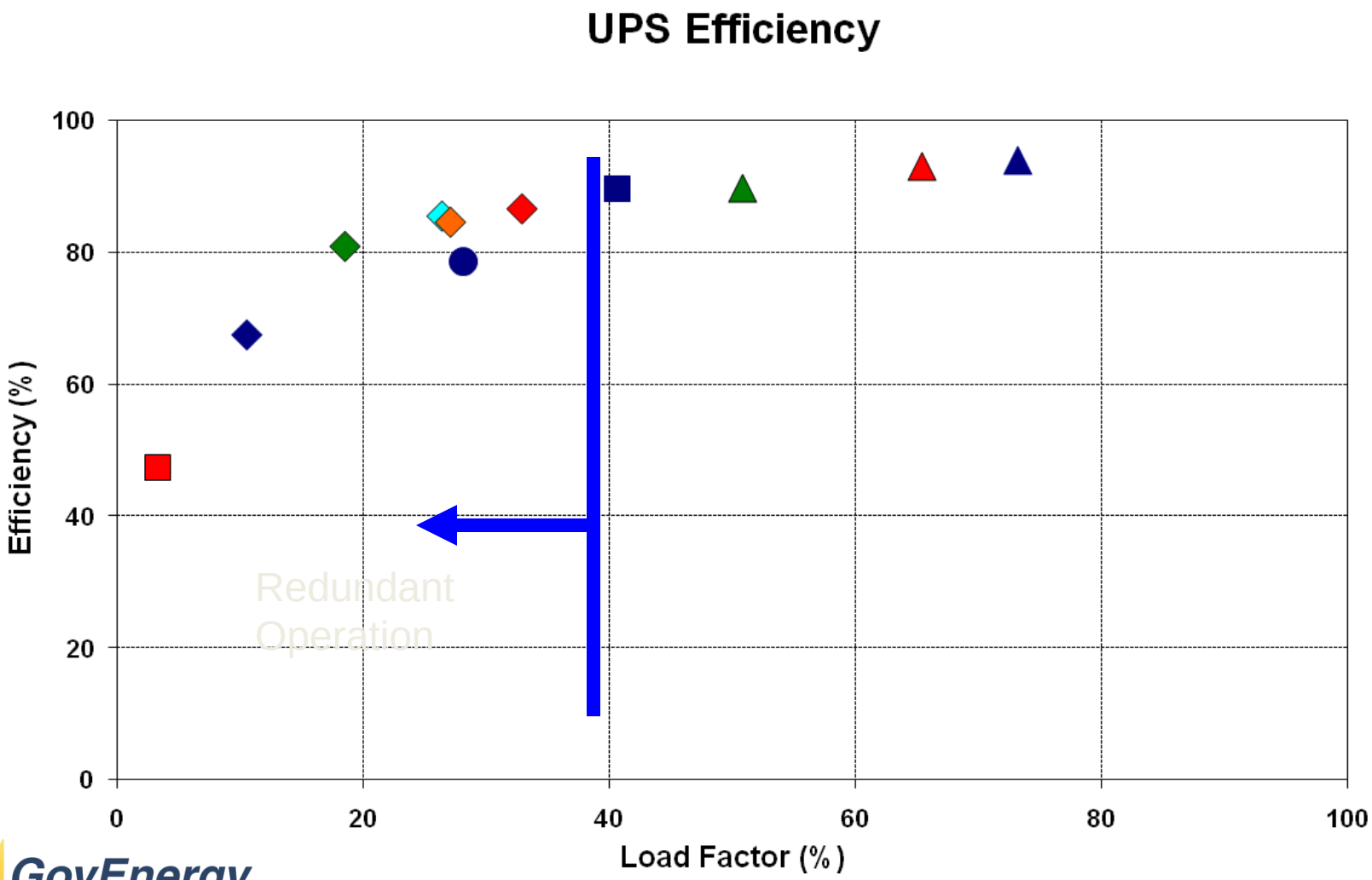
Measured UPS Efficiency



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Resources

FEMP Federal Energy Management Program

http://www1.eere.energy.gov/femp/program/data_center.html

Berkeley Lab

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

ENERGY STAR

http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

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

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