Monitoring Kit for Data Centers

Rod Mahdavi, P.E. LEED AP
Lawrence Berkeley National Laboratory
September 2014

Learning Objectives

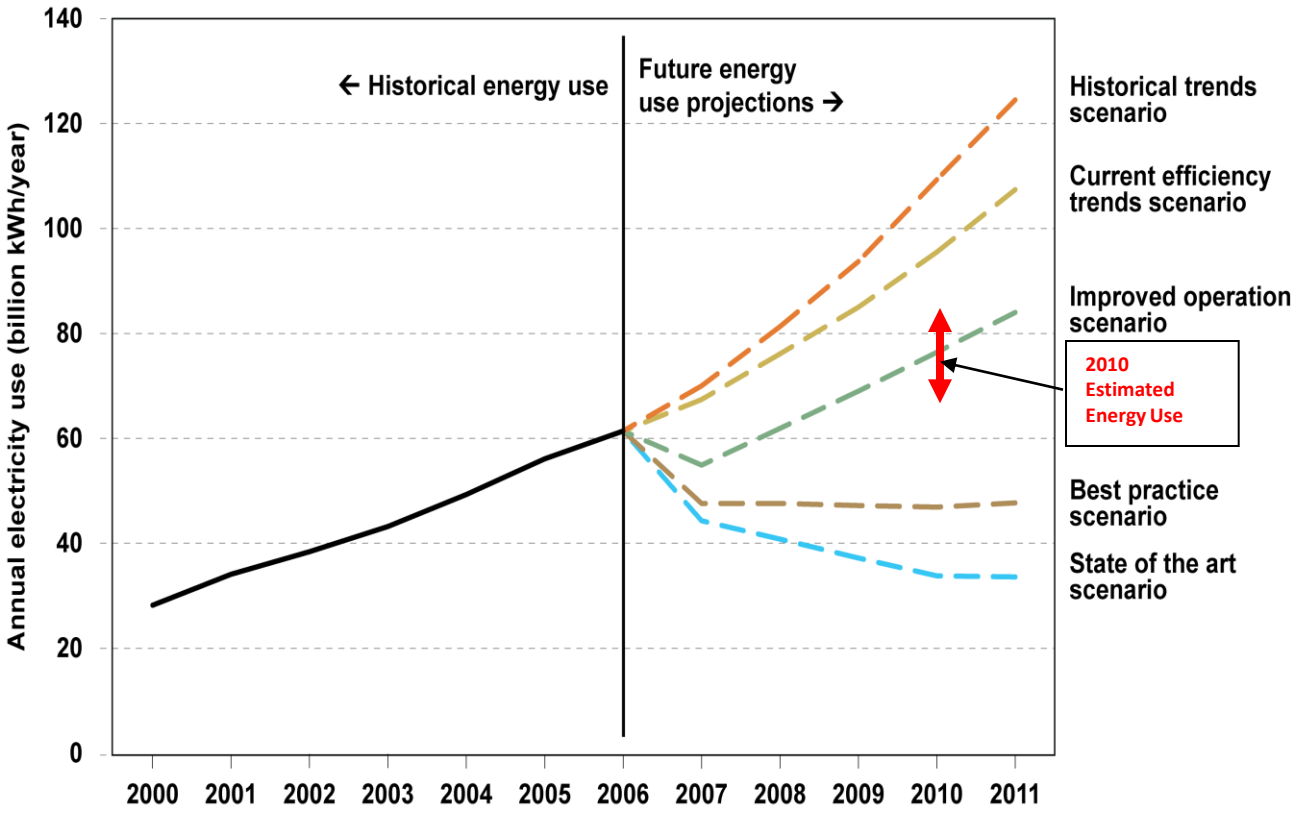
- Why is energy use in Data Centers targeted?
- How can energy use be optimized?
- What is the role of monitoring, what is a monitoring kit?
- Energy savings can be achieved through monitoring.

Data Centers Energy Use

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2% of US Electricity consumption

Potential to double in next 5-7 years



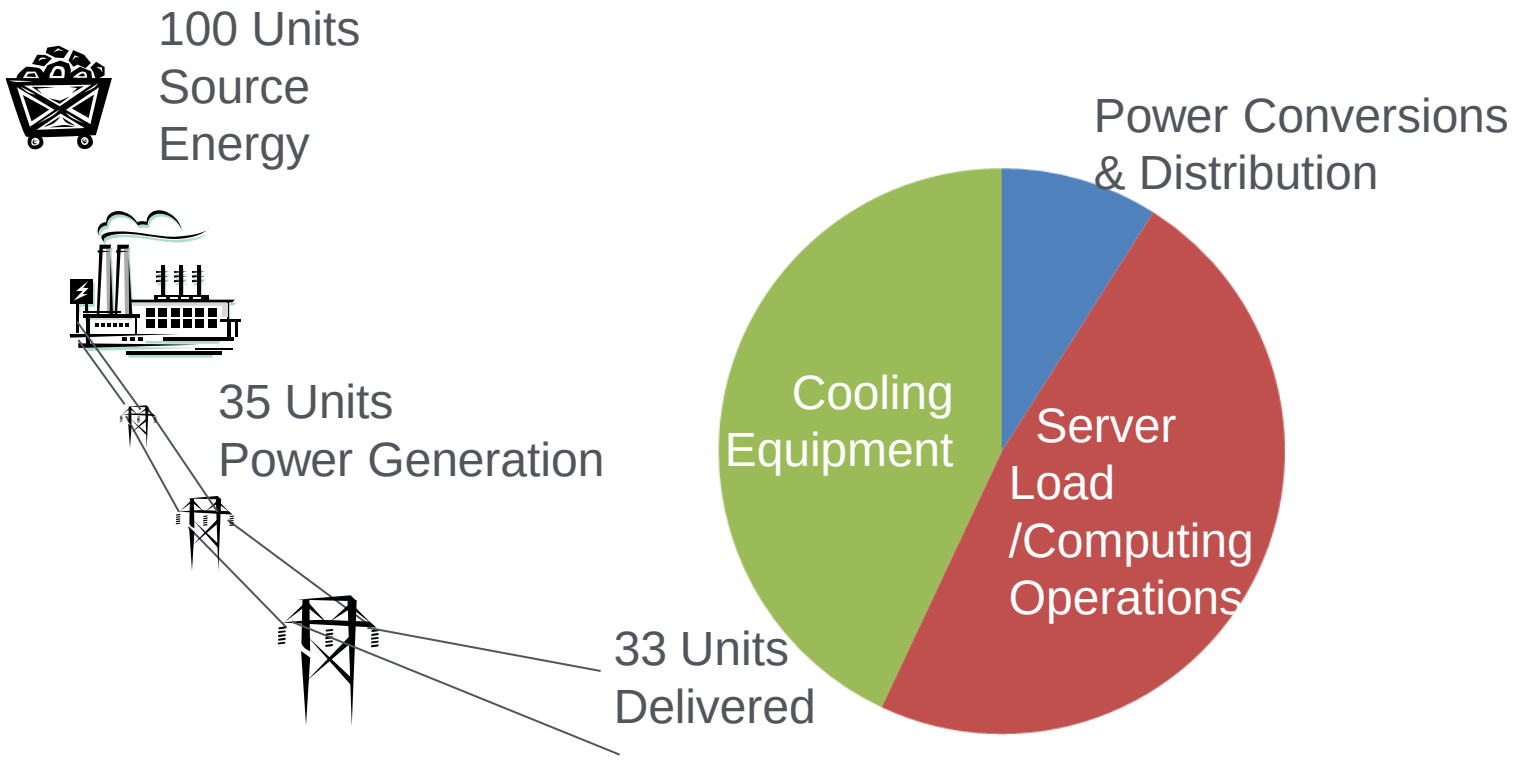
Modified from the EPA Report to Congress 2007

Losses from Source to Use

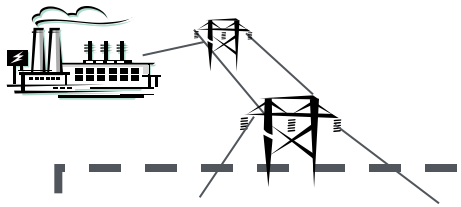
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

(Energy Efficiency = Useful computation / Total Source Energy)

Typical Data Center Energy End Use



Saving 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

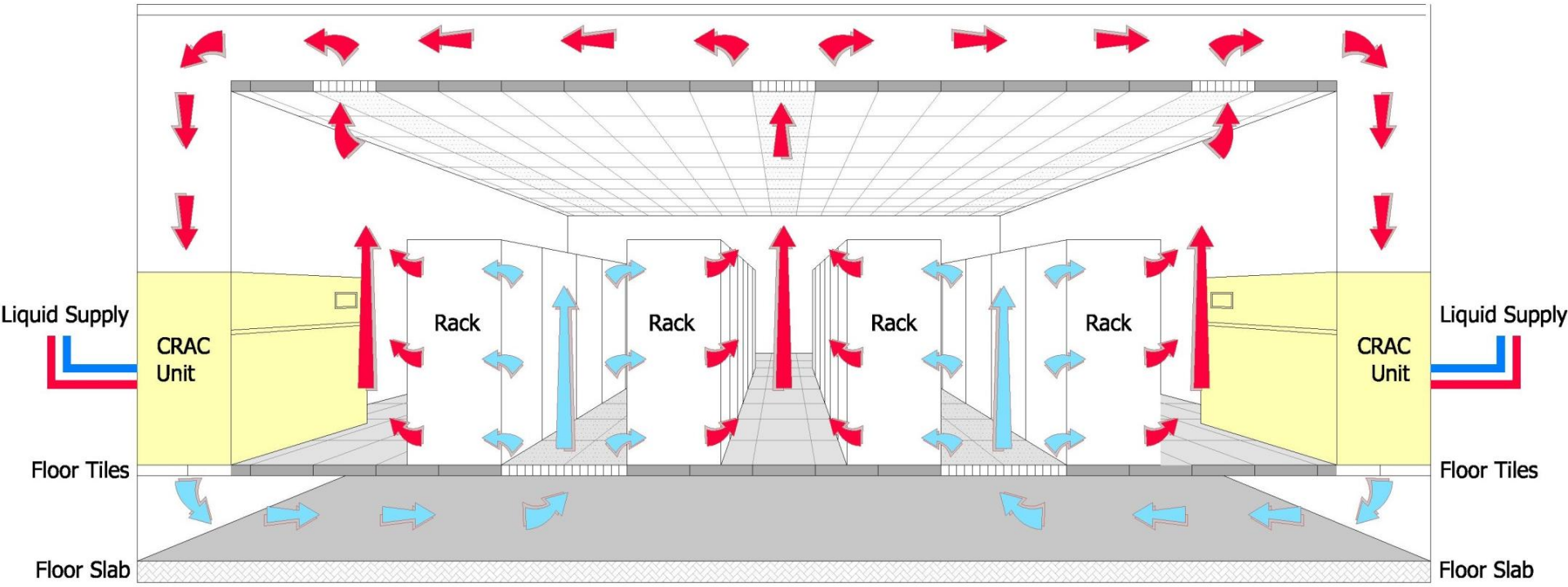
Cooling

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

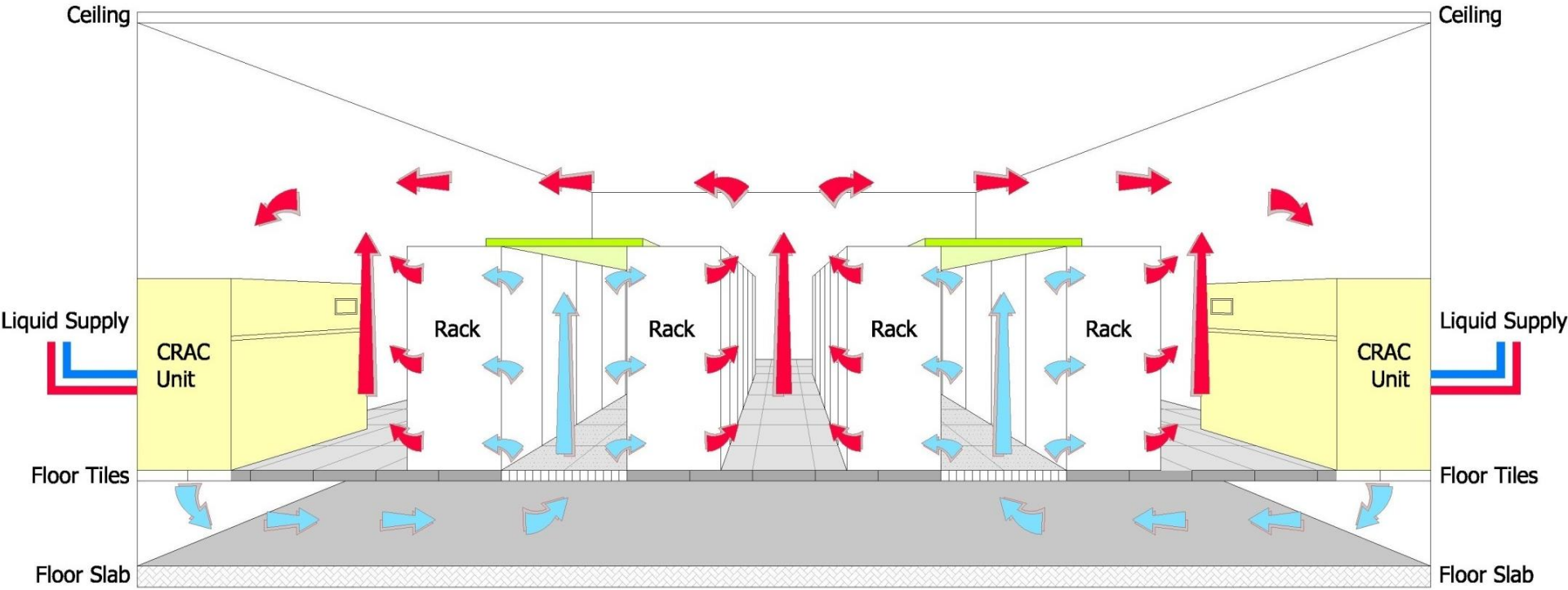
Alternative Power Generation

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

Typical Airflow Example

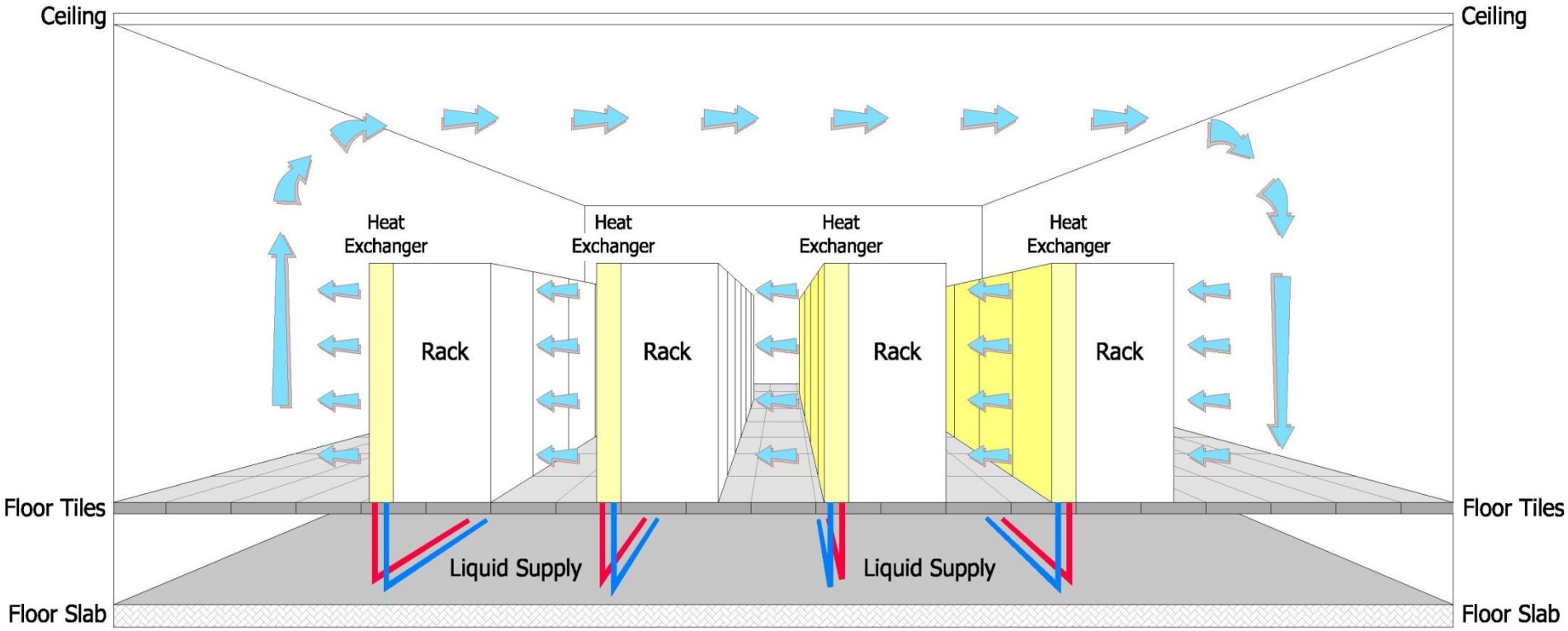


Cold Aisle Airflow Containment Example



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

Air Distribution – Rack-Mounted Heat Exchangers



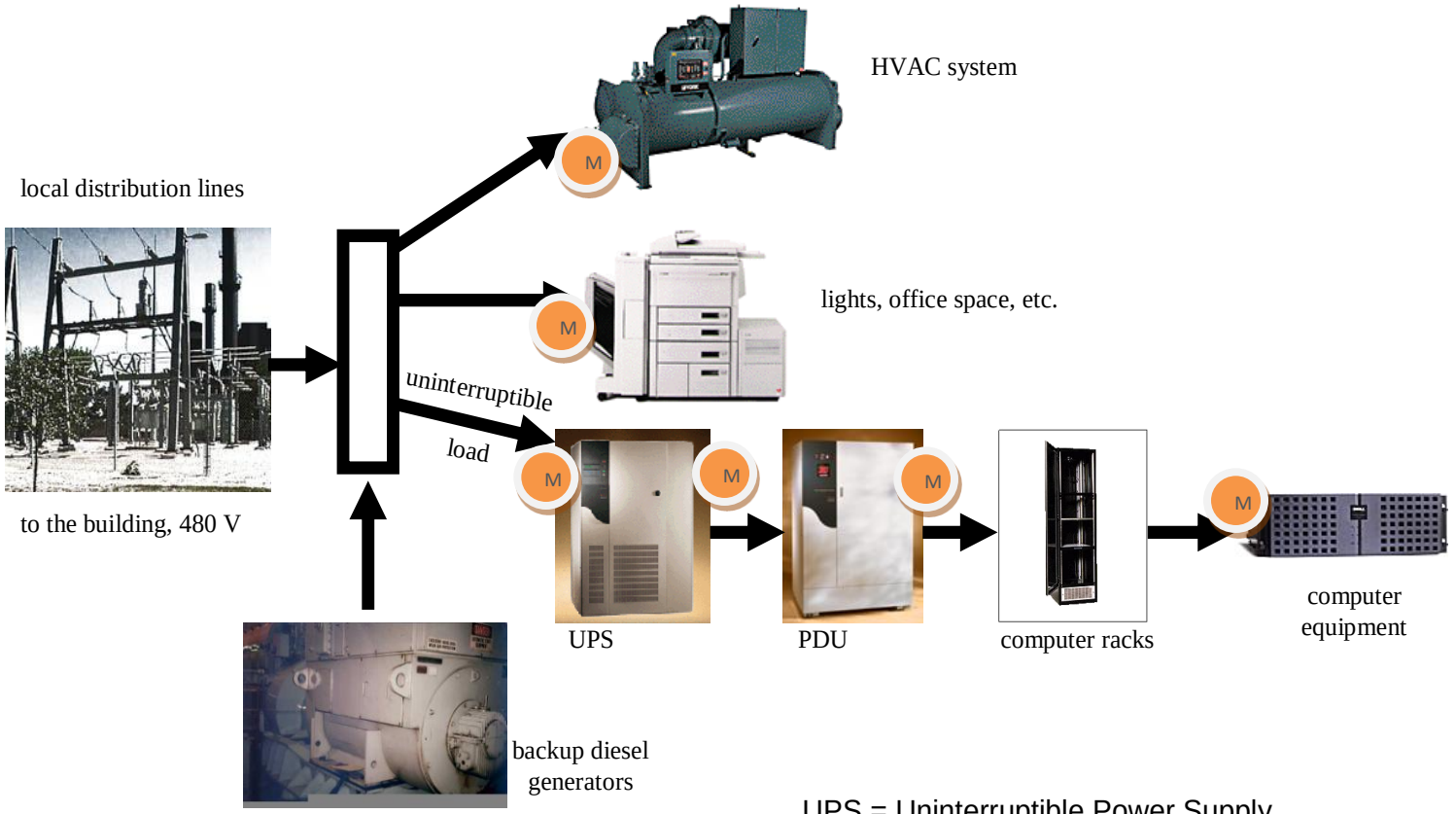
Metrics Made Possible with Wireless Technology

- Power usage effectiveness (PUE), ratio of total energy to IT energy
- Air supply temperature at IT intake (degF)
- Relative humidity range at IT intake (percent)
- Cooling system efficiency (kW/ton)
- Airflow efficiency (watts per cubic feet per minute, W/cfm)
- Power distribution system efficiency (percent)
- Lighting power density (watts per square foot, W/sf)

Power Monitoring

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Electricity Flows in Data Centers

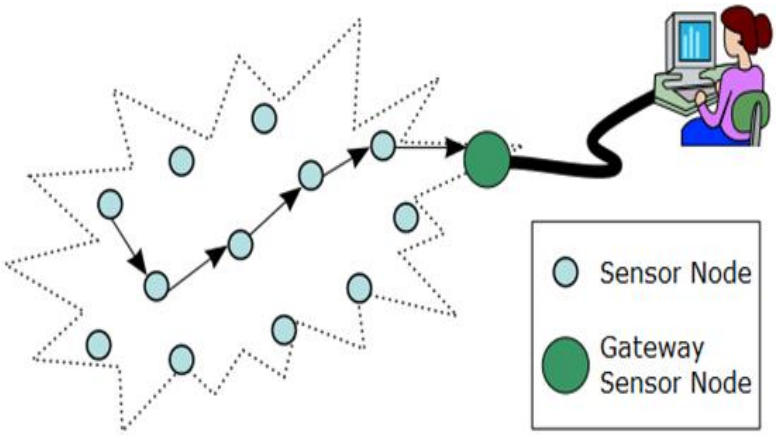


UPS = Uninterruptible Power Supply

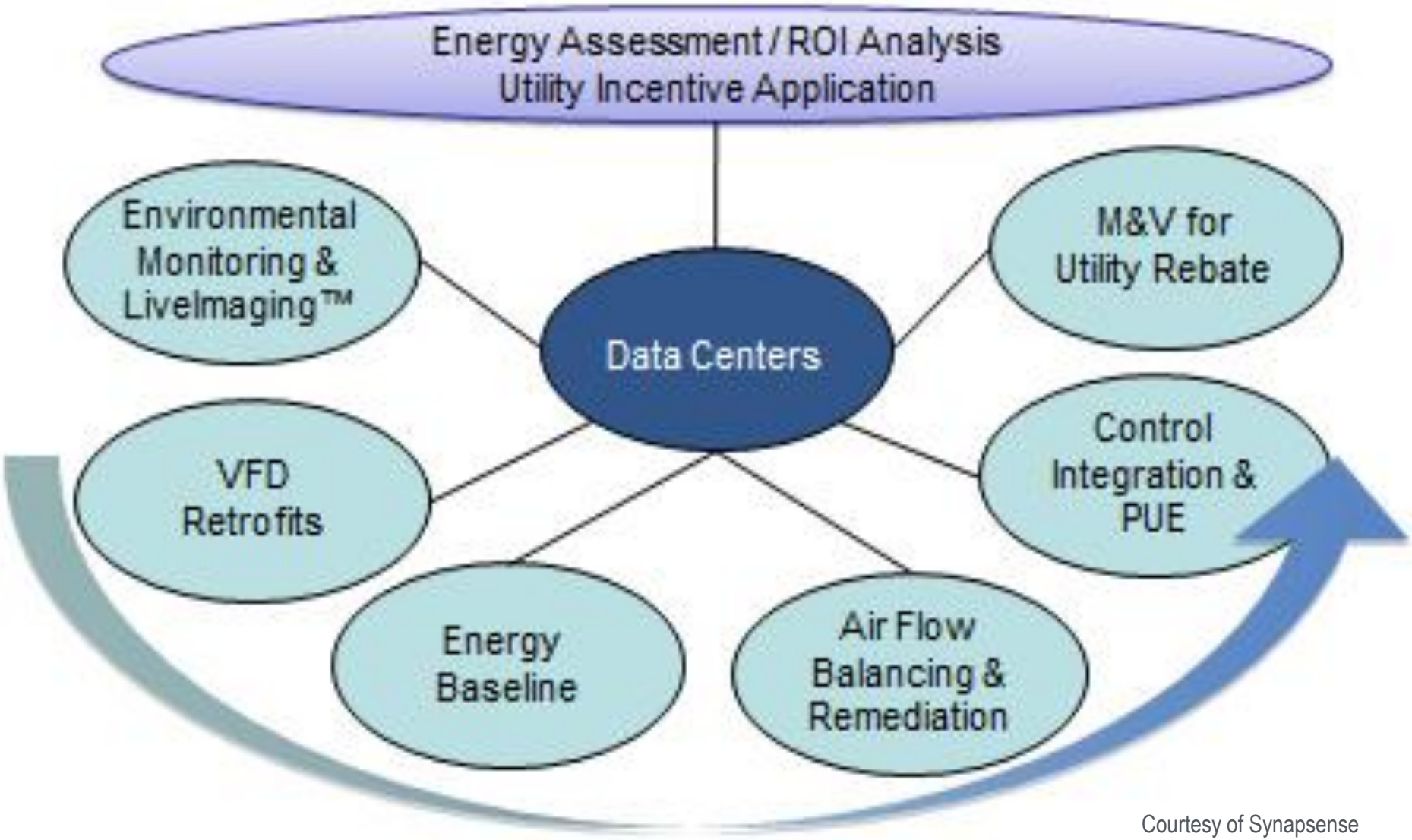
PDU = Power Distribution Unit;

Granular Monitoring

- Identify baseline energy usage and improvement opportunities
- Measure real-time power usage and calculate power usage effectiveness (PUE), defined as total annual energy used divided by IT equipment annual energy use
- Interpret temperature, humidity, and sub-floor pressure differential data from hundreds of sense points into intuitive live imaging maps
- Monitor environmental conditions in order to stay within recommended and/or allowable ASHRAE temperature and humidity and provide alerts when boundaries are exceeded.



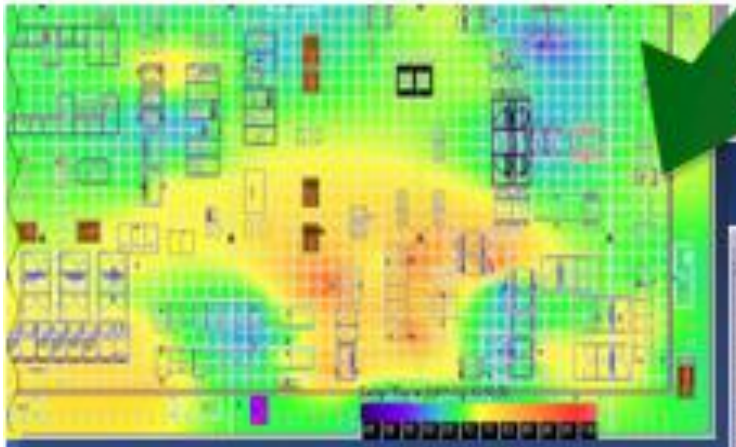
Energy Savings & Return on Investment

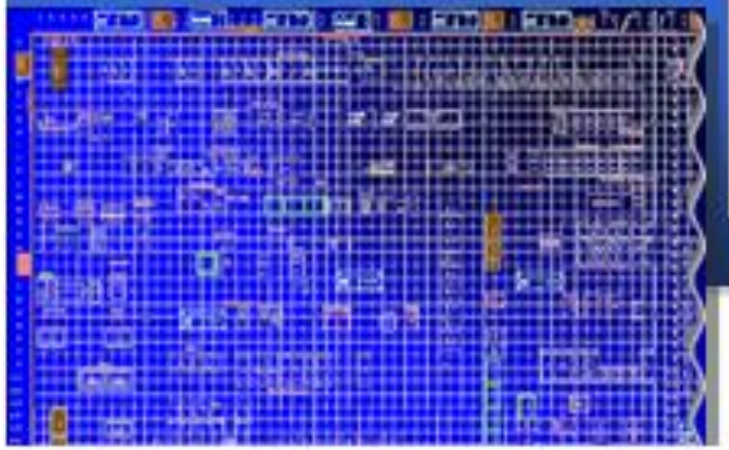


Courtesy of Synapsense

The Process

1. Visualize Temp & Humidity





2. Visualize Air Pressure

3. Analyze

- Rack and CRAC/CRAH view
- Air pressure, humidity, temp, power
- Historical trending/graphing

4. Implement Changes

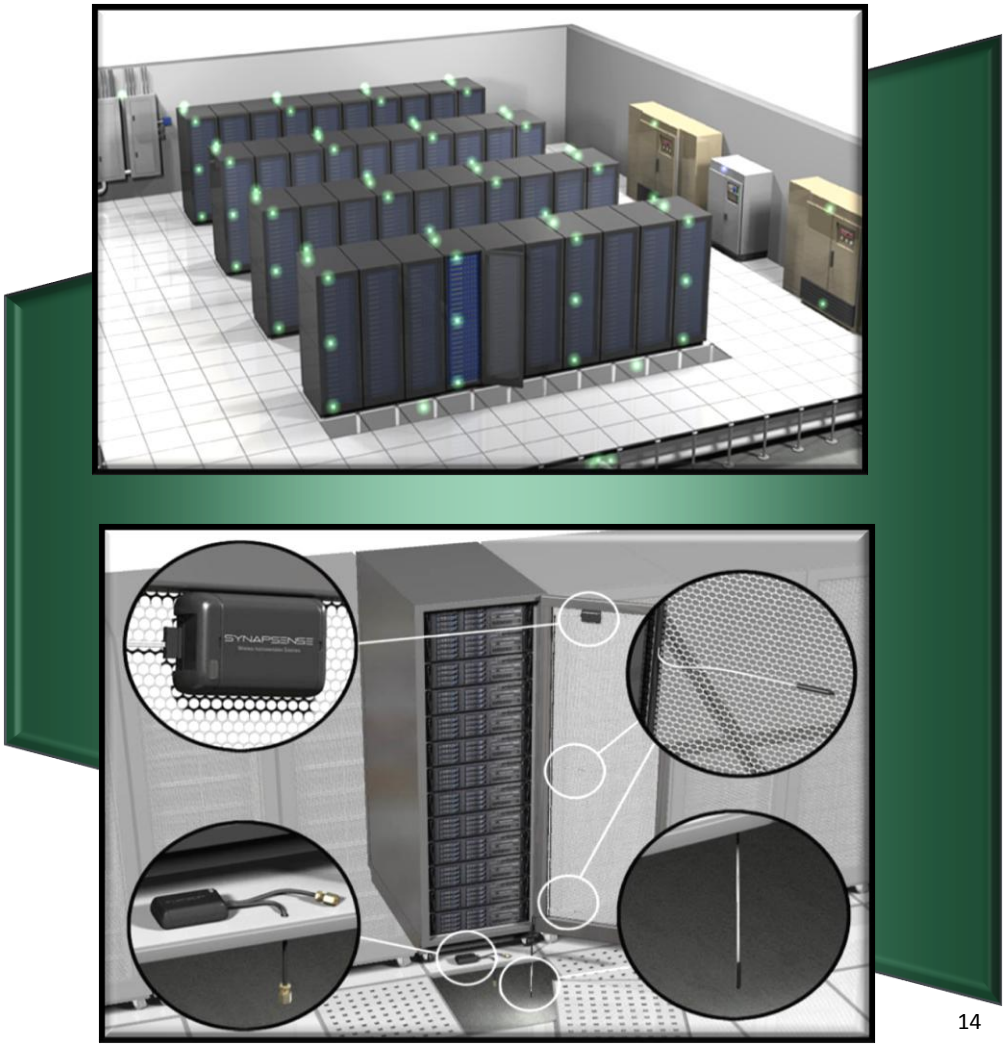
5. Visualize Change Results

Solution System

Basic Components:

1-The wireless network,
2-Console application,
3-Browser-based user interface.

Temperature
Humidity
Pressure
CW BTU
Power



Solution Sensors

- Thermal rack nodes and temperature sensors

- CRAC/CRAH thermal nodes measuring temperature and humidity

- Differential pressure transmitters

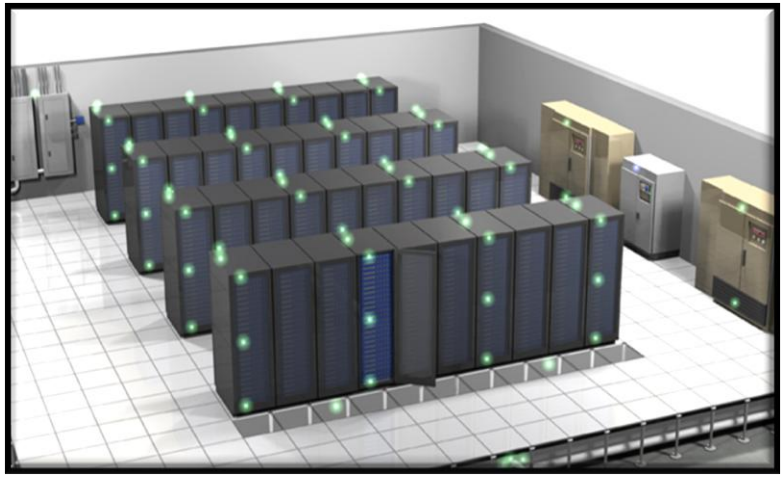
- Current transmitters
- Voltage transformers

- Gateway

Wireless Monitoring Kit

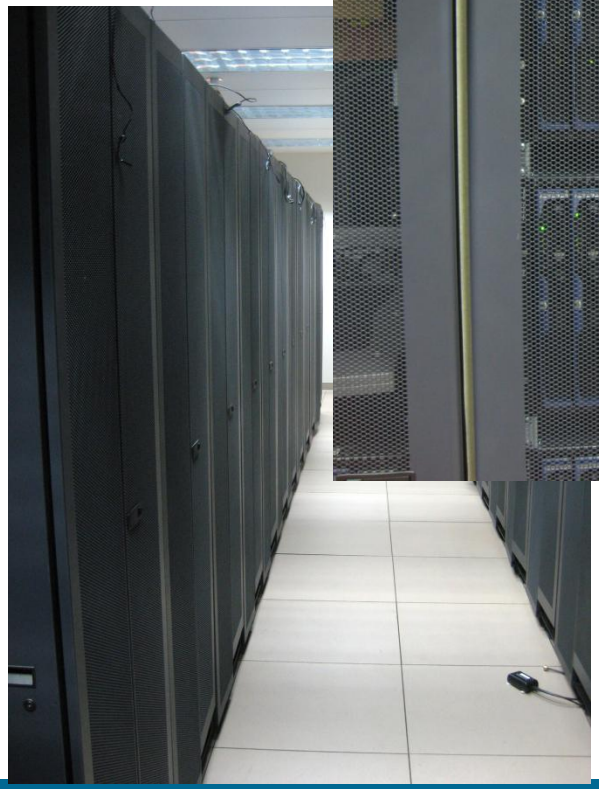
- Concept: Deploy a wireless monitoring system with enough capability to obtain at least 80% of the data compared to a permanent full installation. Additional needed data to be obtained by other existing BMS systems, engineering calculations, balance reports, or other estimation.
- It can be installed, moved, or taken down quickly.
- Monitoring performance

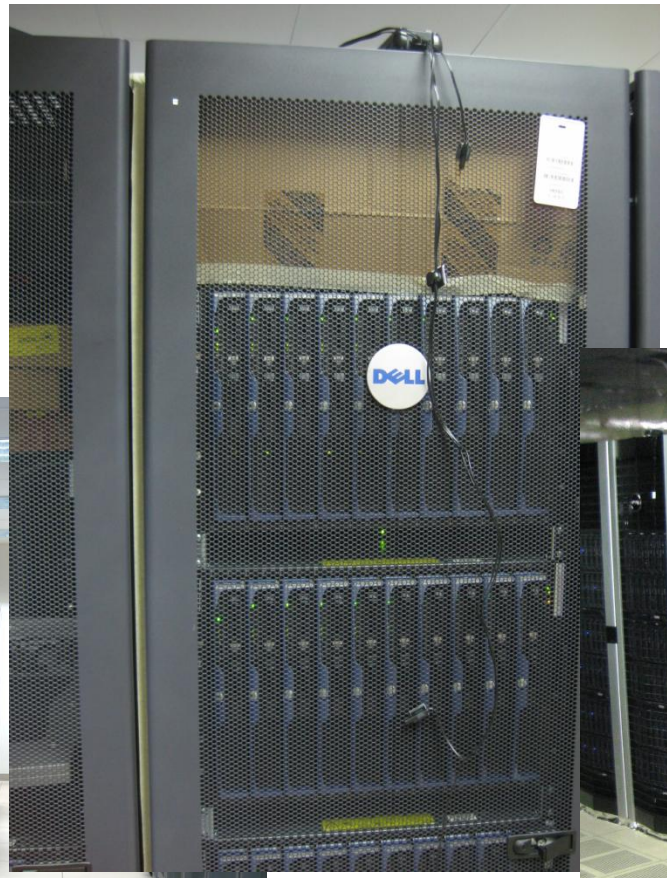
before and after air management changes (or other efficiency measures) are made provides documentation of savings.



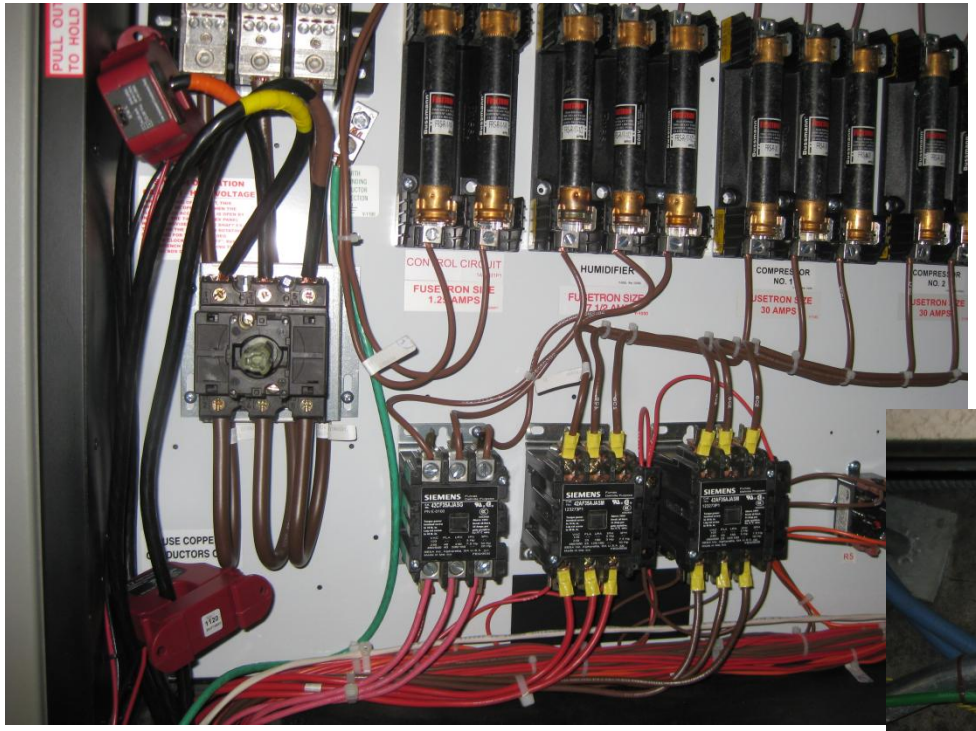
Portable Wireless Kit

Portable Wireless Kit

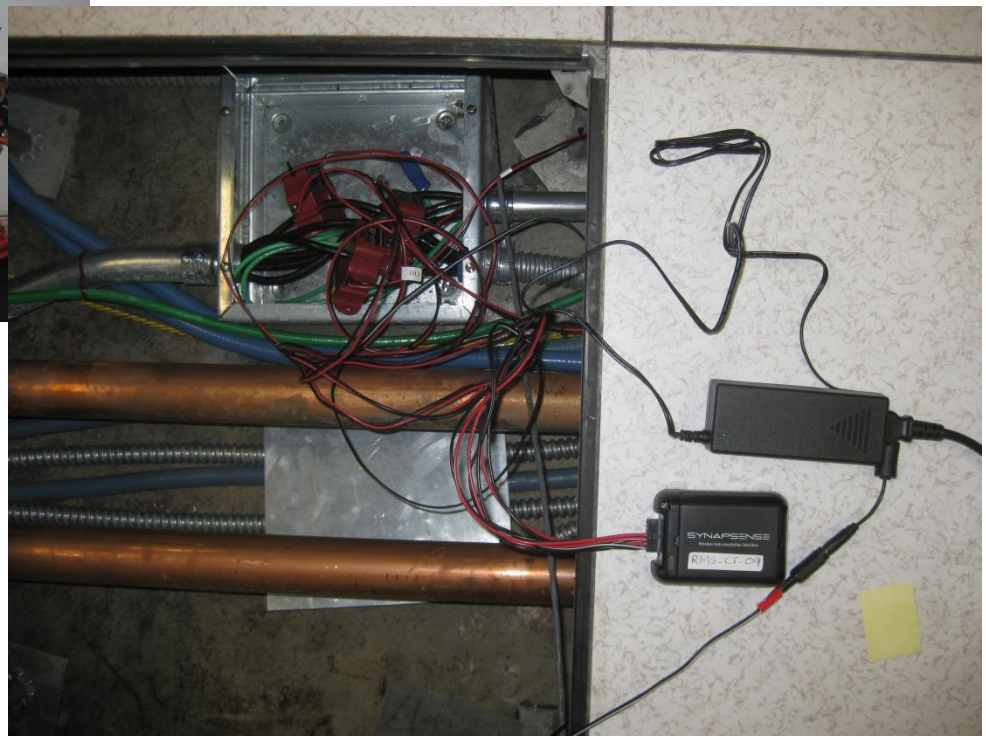




Power CTs



CTs on wires inside CRAH panel



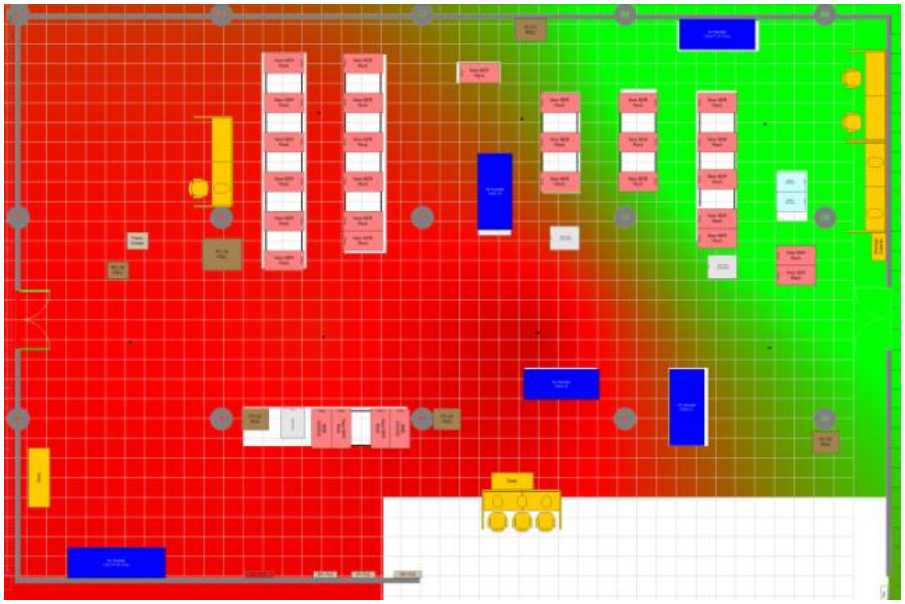
CTs on wires in junction box

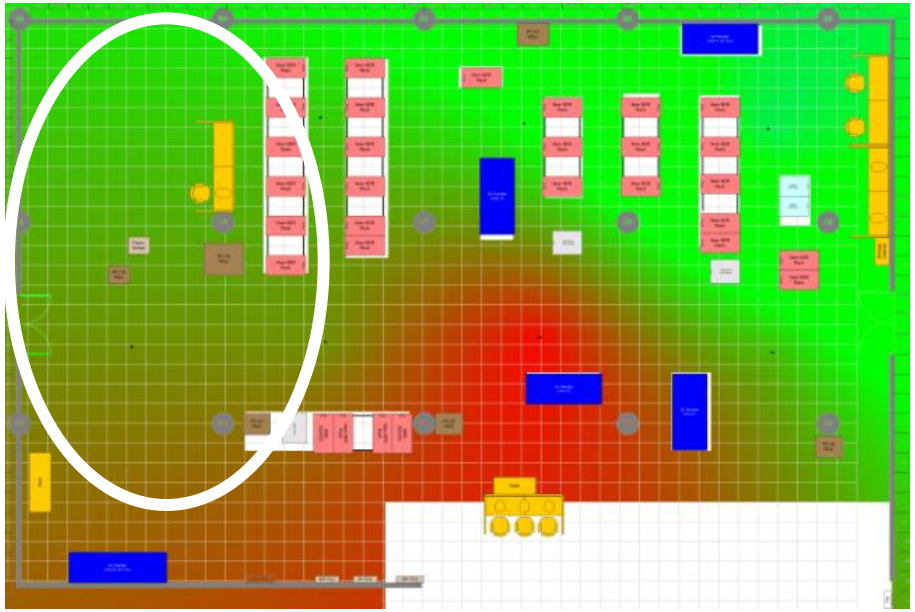
Low Cost Savings

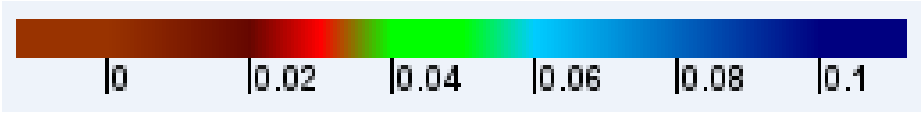
- **Environmental conditions adjustments**
- **Air management improvements**
- **Chiller plant**

GSA Building 1 DC

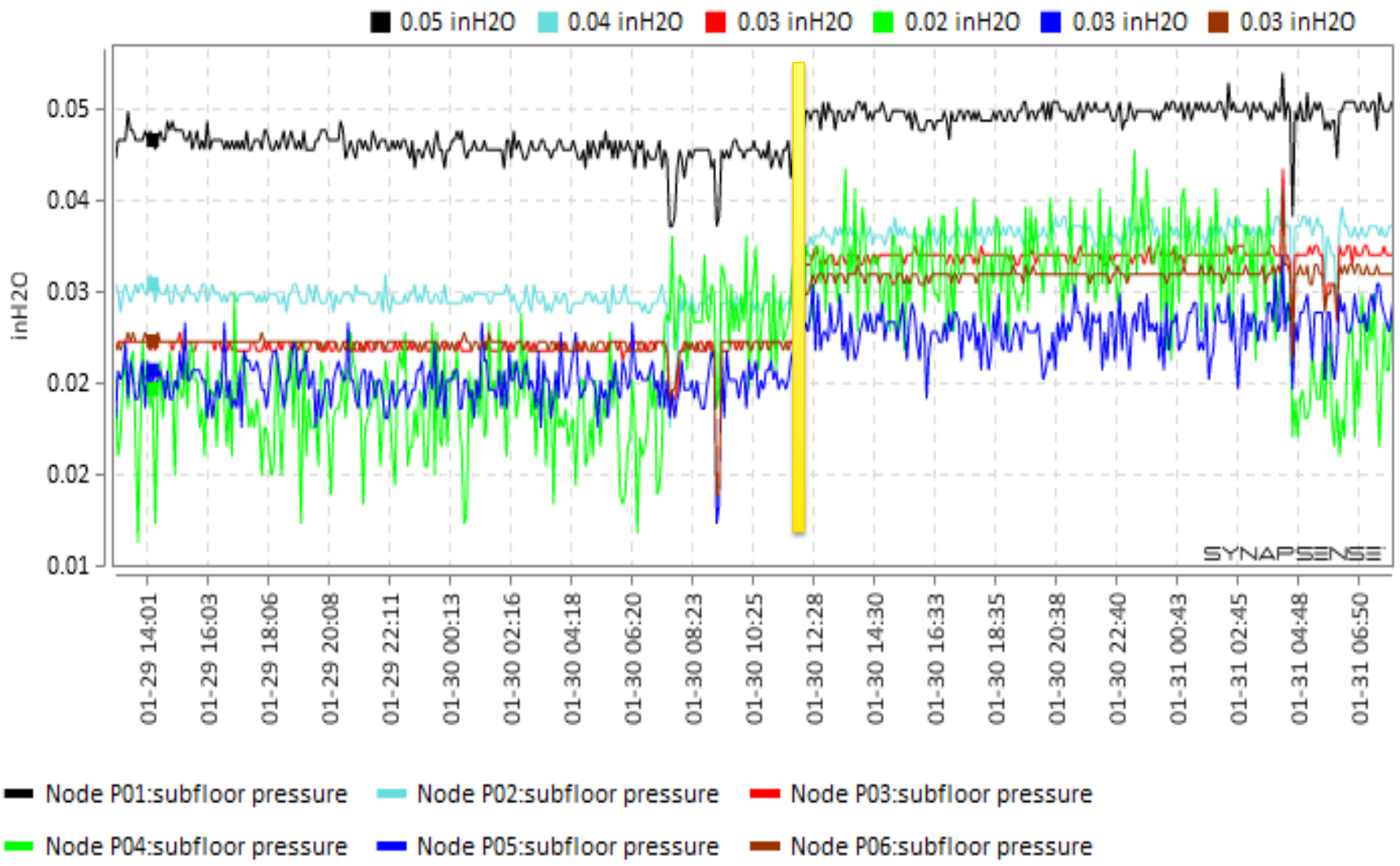
GSA Building 1 DC



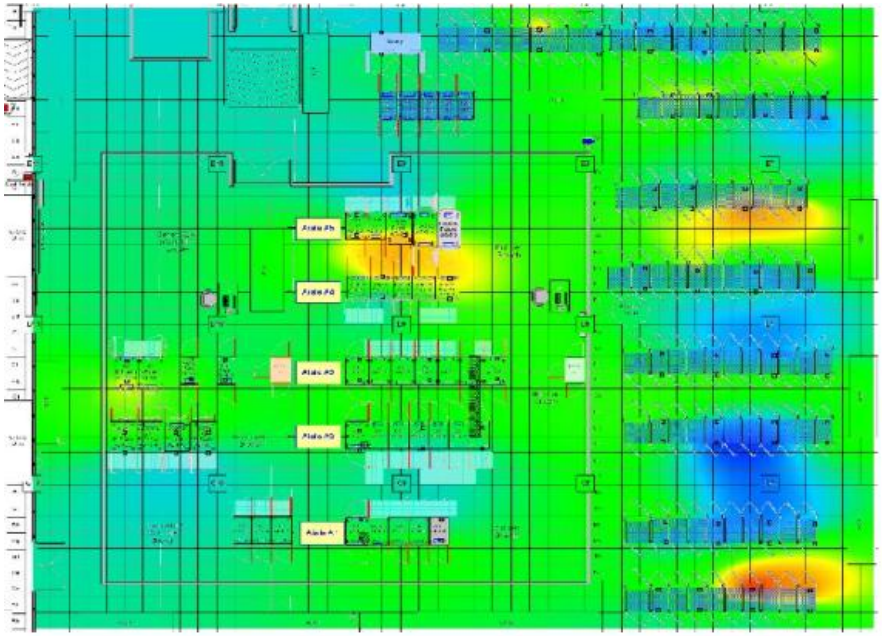


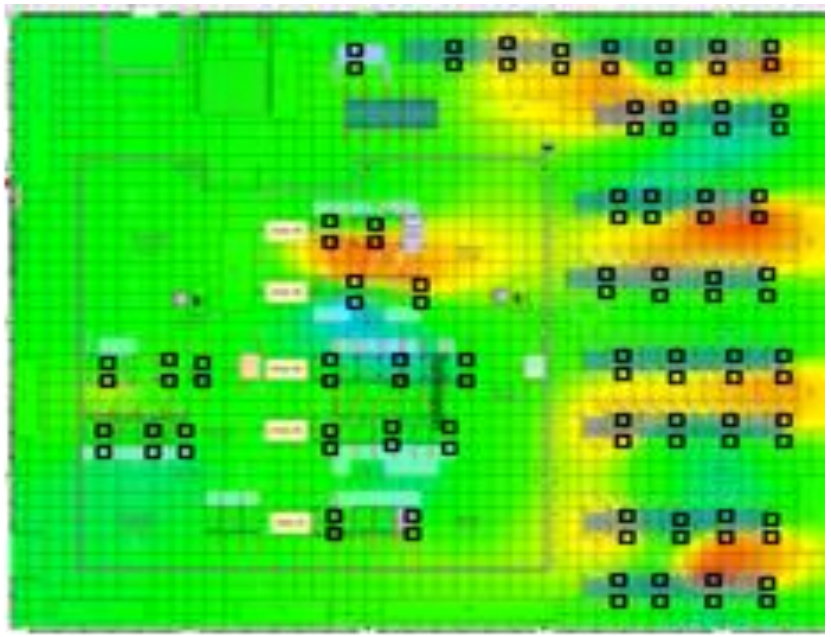


GSA Building 1 DC



GSA NITC Facility





Before

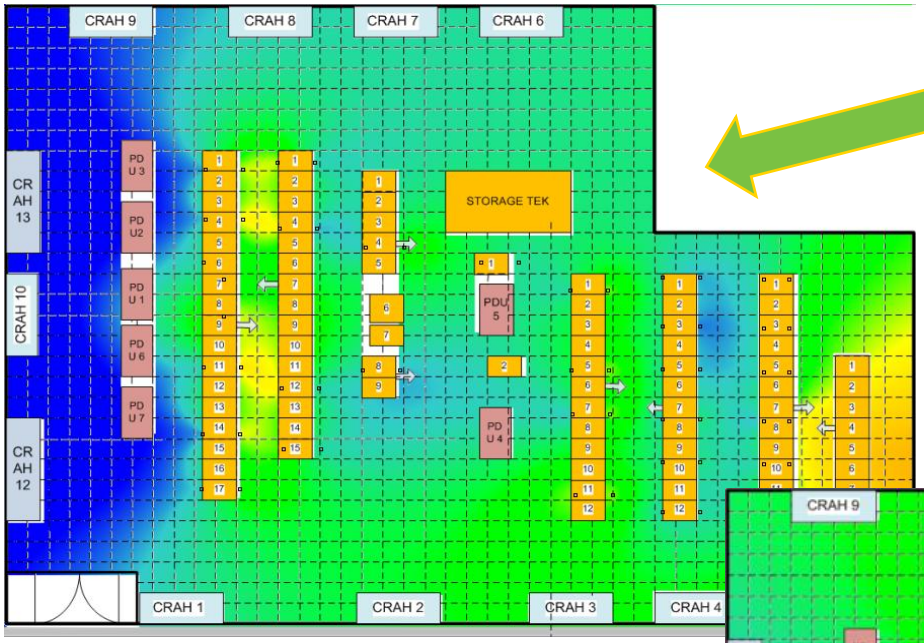
After Enclosing the hot aisles

Thermal map taken with the test kit showing before and after conditions in the data center

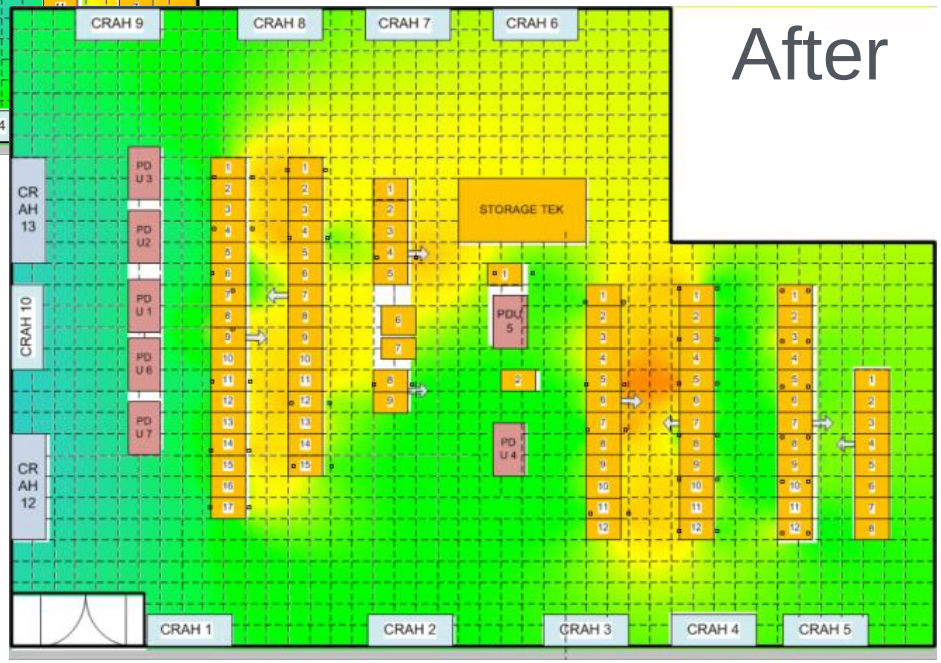
MHPCC Facility

Curtain on top of the racks

MHPCC Facility



Before trials begin



After

RAT increased from 74degF to 84degF

Case studies HPC DCs

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Site	Current IT Load kW/sqft	Current IT Load kW	Elec Dist. Loss kW	Cooling Load kW	Fan Load kW	Other users kW	Current PUE	Potential PUE
Site 1	120	2,000	150	750	200	260	1.68	1.64
Site 2A	180	1,050	170	450	195	150	1.92	1.57
Site 2B	240	810	170	370	160	95	1.98	1.63
Site 3	260	1,670	100	700	125	120	1.63	1.56
Site 4	130	550	158	180	47	65	1.82	1.71
Site 5	130	510	73	265	80	33	1.88	1.42

In Site 5 (MHPCC), by increasing SAT, $150,000 was saved annually.

Case study –A DoD DC

Summary of Energy Savings Estimates	Savings			Cost	Payback
	kW	kWh/yr	$	$	years
Turn off excess CRAHs	145	1,250,000	75,000	5,000	0
Install VFD on CRAHs	325	2,847,000	170,000	340,000	2
Raise CHWS Temp	35	303,000	18,180	20,000	1.1

During DC baselining, by turning off 35% of CRAH units, $75,000 was saved (annually).

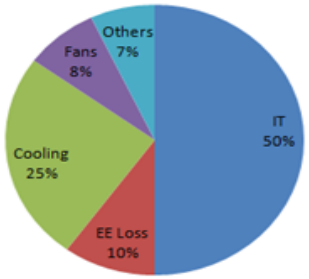
Dashboard User Requirements

- Easy access to information
  - minimal preparation time
- Standardized format of the information
  - facilitates understanding
- Overview and detailed information
  - exceptions or outliers can be quickly detected for further investigation
- Ability to share information with colleagues
  - Exporting to file formats such as Adobe Acrobat (PDF), Word, PowerPoint and Excel
- Ability to act
  - actionable information
  - Otherwise what is the value?

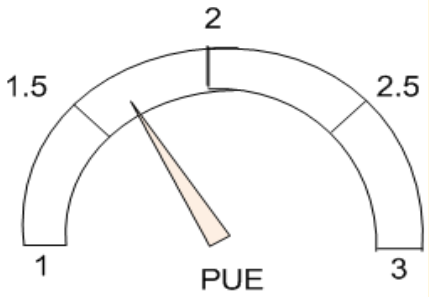
Typical Dashboard

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

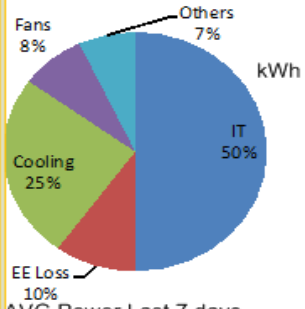
Hourly Energy Cost $500



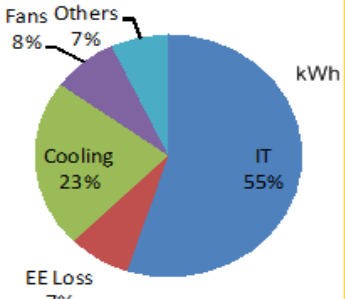
Percent POWER USE Real Time



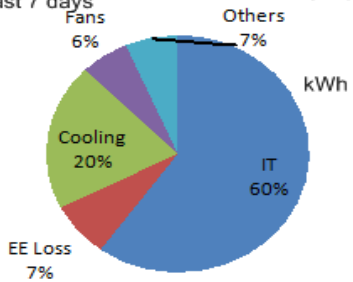
Last 7 days	$	50k
Last 30 days	$	150k
Last 12 months	$	800k



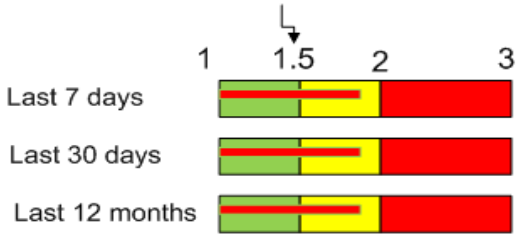
AVG Power Last 7 days



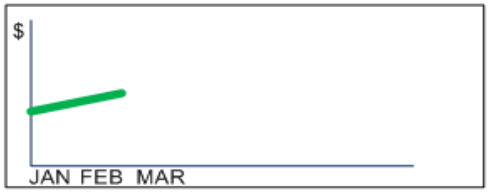
AVG Power Last 30 days



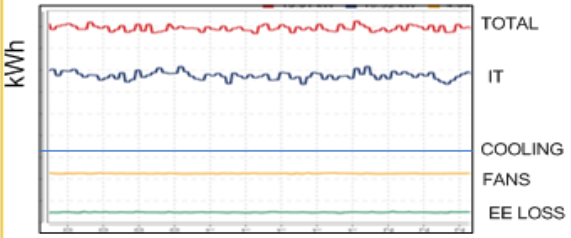
AVG Power Last 12 months



Avg PUE



ENERGY COST

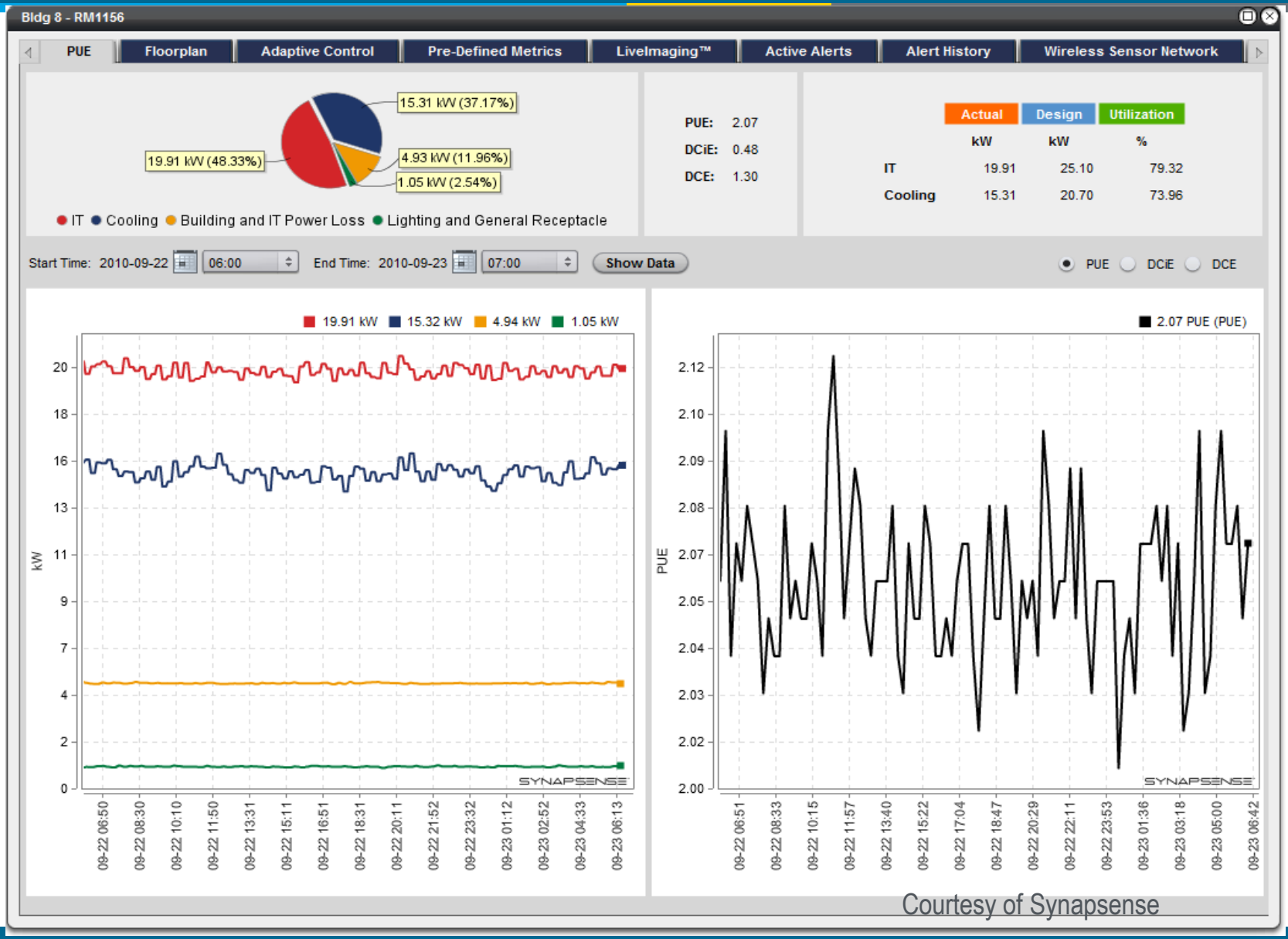


ENERGY USE trend

PUE trend

Vendor Dashboard

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Courtesy of Synapsense

Summary

- Projects using the kit have been conducted in mostly government agencies specially DoD
- Real or potential savings of tens of thousands of $ in each site
- Simple payback ranges from just few month to a few years
- Physical monitoring work at site takes about a week. Report is done in 2-3 months (elapsed time).
- Implementations of recommended EEMs has been immediate in some of the sites and in some sites have not been implemented yet mostly because of lack of funds.
- Simplicity of implementing the measurement, visualization of the problem and resulted attractive simple paybacks are the main reasons for success.
- Disconnect between IT and facility is a problem.
- Stake holders' involvement and interest is important.

References

- Assessment Protocol:

http://www1.eere.energy.gov/industry/datacenters/pdfs/data_center_assessment_process.pdf

- Metering Protocol:

http://www1.eere.energy.gov/femp/pdfs/hpc_metering_protocol.pdf

- Data Collection Protocol:

http://www1.eere.energy.gov/femp/pdfs/datacollectionprotocol.pdf

- Self-benchmarking Guide for Data Center Infrastructure: Metrics, Benchmarks, Actions

http://hightech.lbl.gov/benchmarking-guides/data.html

- Full report of GSA use wireless monitoring kit

http://www.gsa.gov/graphics/pbs/wireless-sensor-network-final-full-report.pdf

http://datacenters.lbl.gov/

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

CENTER OF EXPERTISE
FOR ENERGY EFFICIENCY IN DATA CENTERS

SEARCH

U.S. DEPARTMENT OF ENERGY · FEMP Federal Energy Management Program · BERKELEY LAB

HOME ABOUT INITIATIVES ACTIVITIES RESOURCES CONTACT US

"While information technology (IT) is improving the efficiency of government, energy use in data centers is growing at a significantly faster rate than any other building segment..."

A new Department of Energy-led CENTER of EXPERTISE will demonstrate national leadership in decreasing the energy use of data centers. The Center will partner with key influential public and private stakeholders. It will supply know-how, tools, best practices, analyses, and the introduction of technologies to assist Federal agencies with implementing policies and developing data center energy efficiency projects.

Initiatives

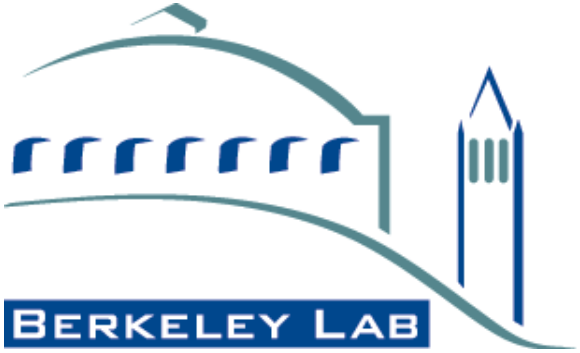
The Data Center Energy Challenge will require participating Federal agencies and other data center owners to establish an efficiency goal for their data centers...

MORE DETAILS

Resources

The Center's activities will include establishing metrics, providing technical assistance to agencies piloting innovative measurement and management approaches...

MORE DETAILS



Questions?

Rod Mahdavi, PE, LEED AP

rmahdavi@lbl.gov

510.495.2259