Data Center Energy Use, Metrics and Rating Systems

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Today's Agenda

- **Introduction**

- **Energy Usage in Data Centers**
  - —**Opportunities for Improvement**
  - —**Selecting a Performance Metric**
  - —**Rating Systems**
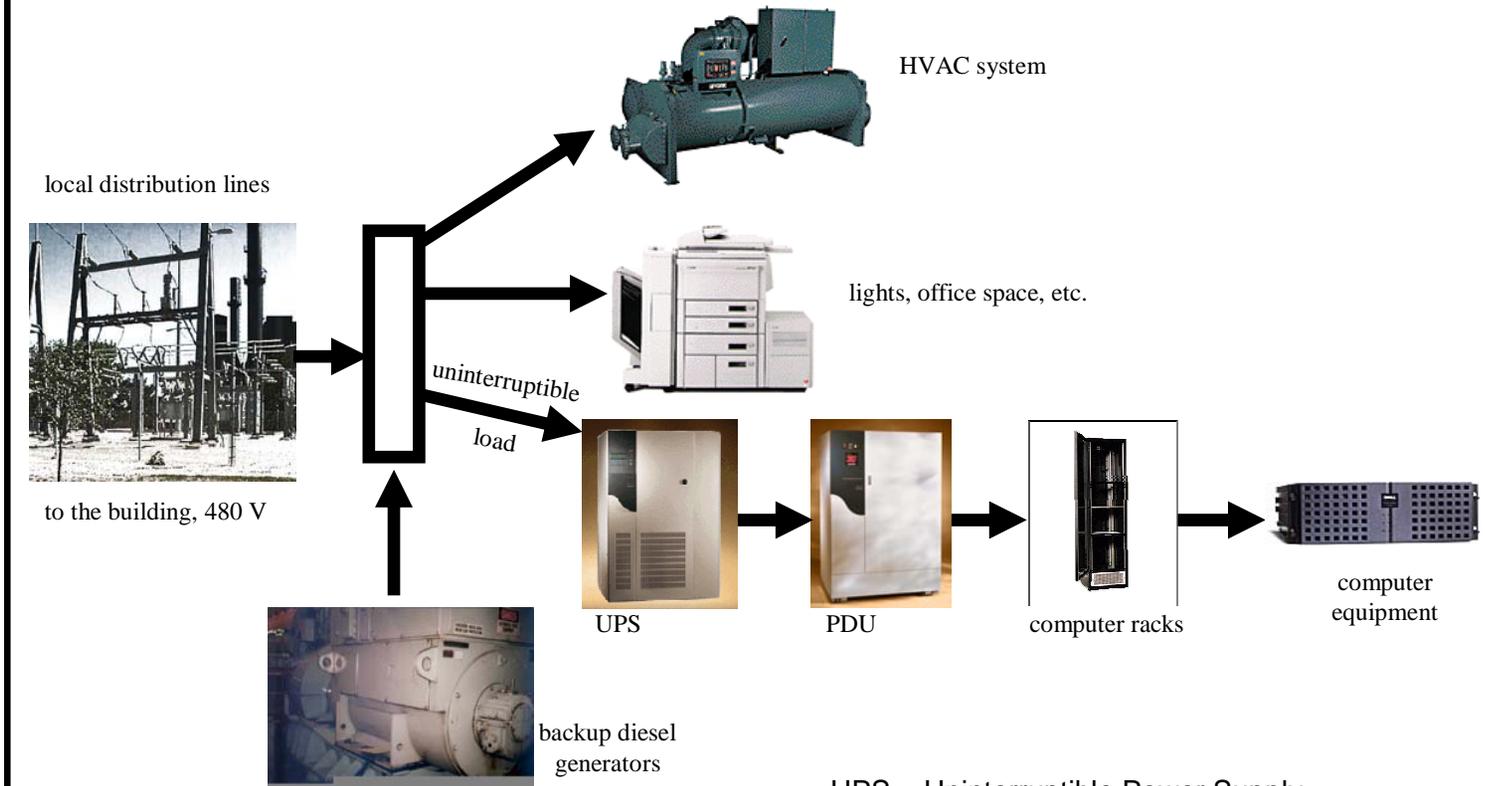
- **Implementing a Metric**

- **Next Steps**

The Data Center Challenge

- **Data Centers 15-40x the energy intensity of typical office buildings**

- **A single rack of servers can be 20 kW**
  - —**$17k per year (at $.10/kWh)** *per rack*
  - —**Hundreds of racks per center**

- **Where are the opportunities?**
  - —**25 data centers benchmarked**

Typical Data Center Design
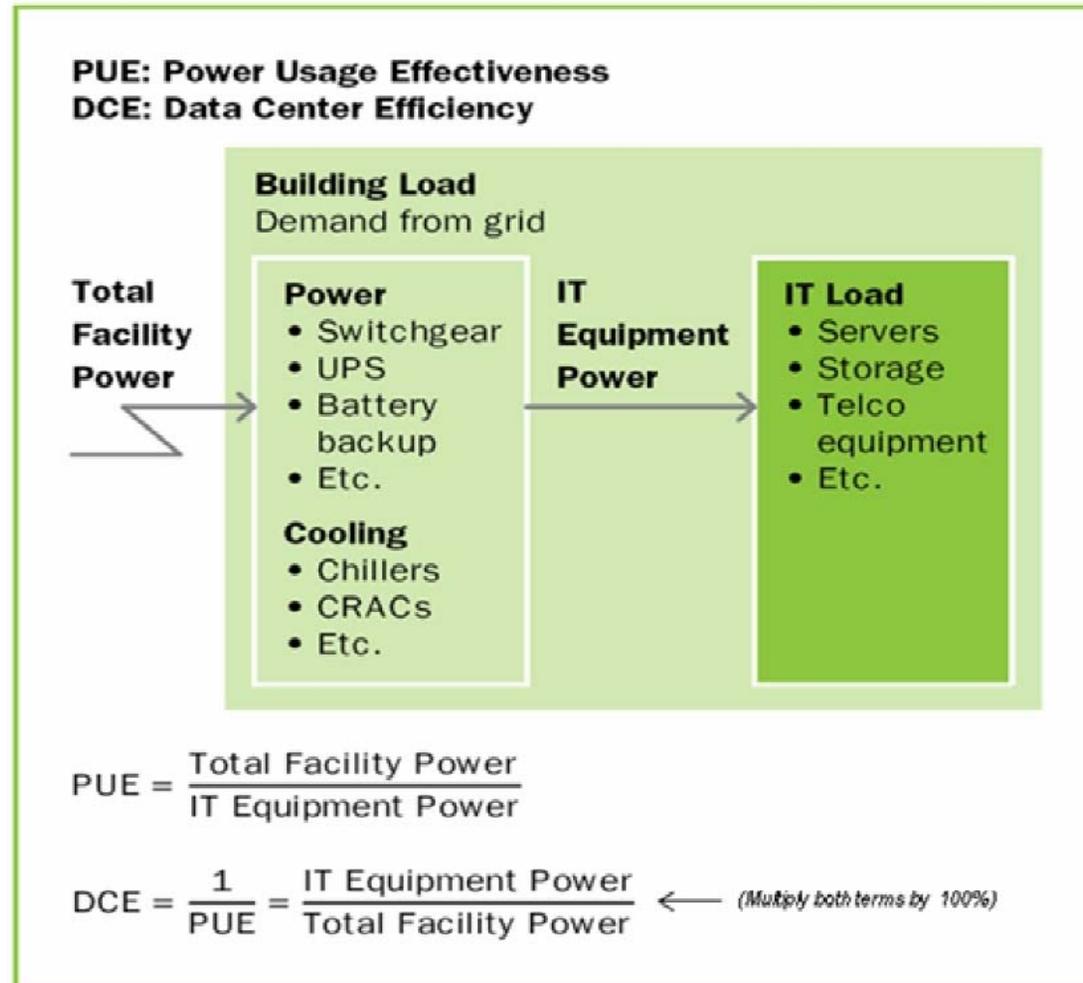

Electricity Flows in Data Centers

local distribution lines

HVAC system

lights, office space, etc.

to the building, 480 V

uninterruptible load

UPS

PDU

computer racks

computer equipment

backup diesel generators

UPS = Uninterruptible Power Supply

PDU = Power Distribution Unit;

Data Center Metrics

- **High-level**
  - **IT/total**
  - **useful work/total**

- **Subsystem**
  - **Power distribution**
  - **HVAC**
  - **Lighting**

- **Facility performance (other than energy)**

E.g. Green Grid,
PUE and DCiE

PUE: Power Usage Effectiveness
DCE: Data Center Efficiency

Building Load
Demand from grid

Total Facility Power

Power
• Switchgear
• UPS
• Battery backup
• Etc.

Cooling
• Chillers
• CRACs
• Etc.

IT Equipment Power

IT Load
• Servers
• Storage
• Telco equipment
• Etc.

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

$$DCE = \frac{1}{PUE} = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}} \quad \longleftarrow \quad \textit{(Multiply both terms by 100\%)}$$

Source: The Green Grid Data Center Power Efficiency Metrics. ©2007.
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High-level Facility Metrics

- **E.g. Uptime Institute:**

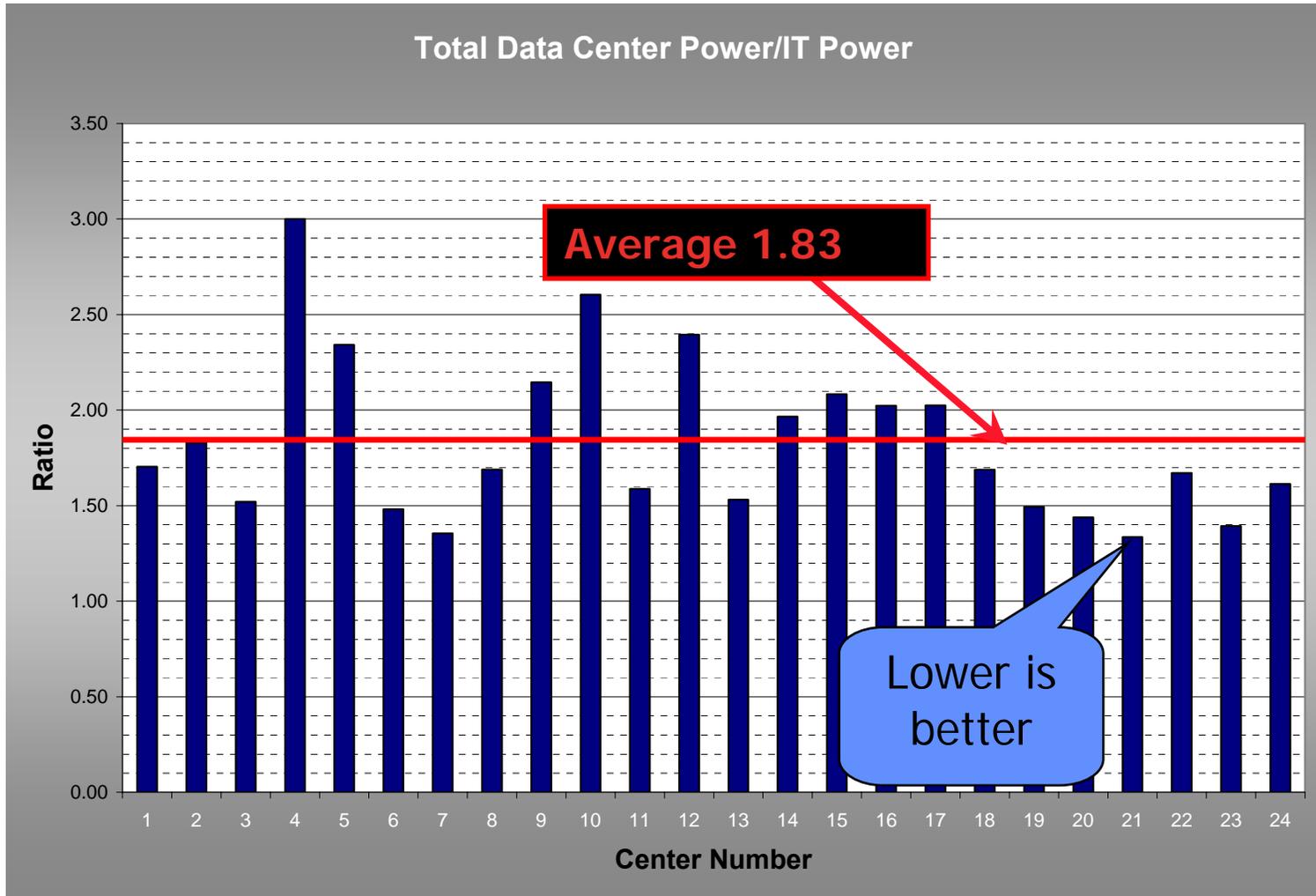 **"Site Infrastructure Power Overhead Multiplier (SI-POM)" = Total/IT**

  Source: "Four Metrics Define Data Center "Greenness" ", Uptime Institute, 2007.

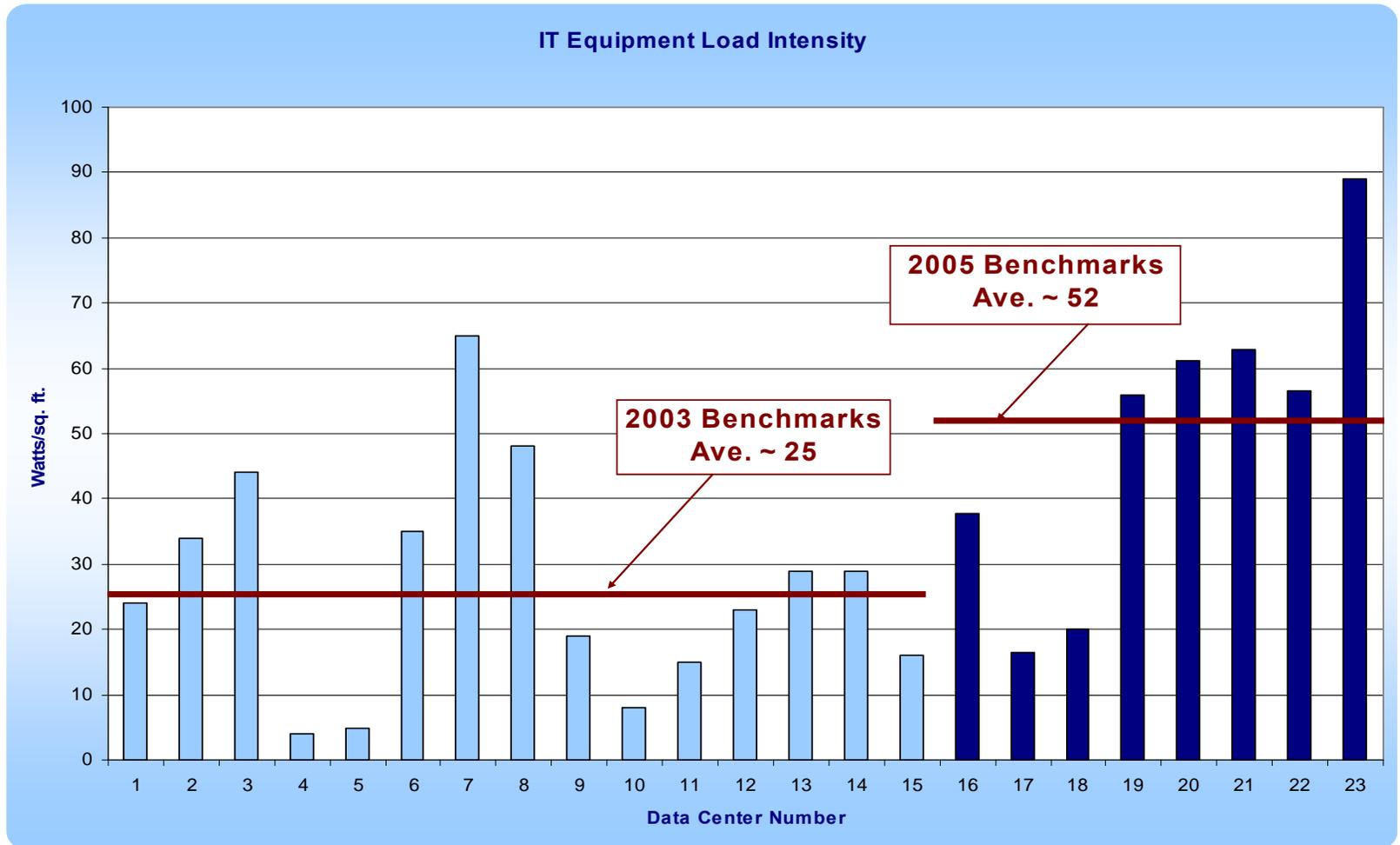# Percentage of electricity delivered to IT equipment

IT Power to Total Data Center Power

Average .57

Higher is better
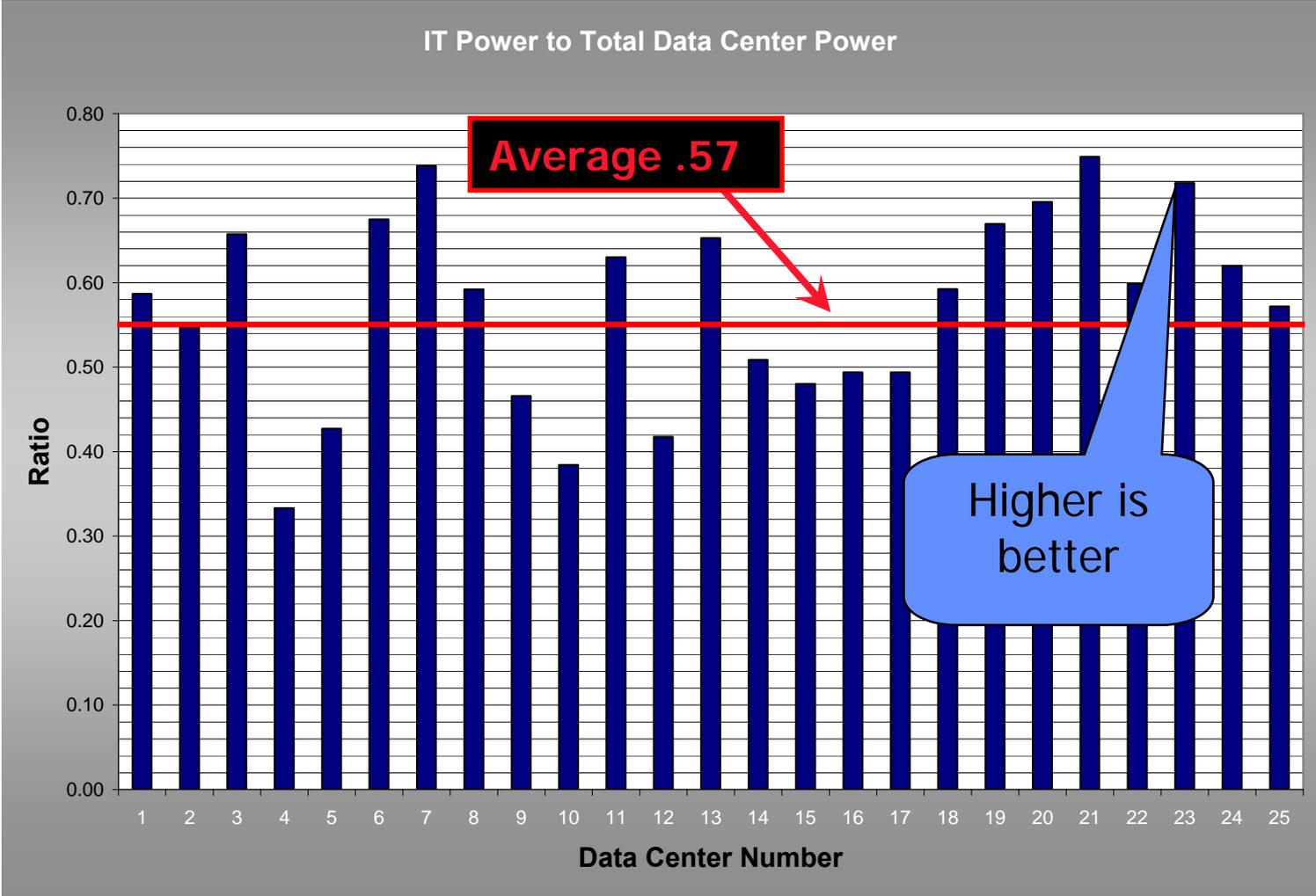
Source: LBNL Benchmarking

Total Power/IT Power

Source: LBNL Benchmarking

Other Data Center Metrics

- **Watts per square foot**
- **Power distribution: UPS efficiency, IT power supply efficiency**
  - **Uptime: IT Hardware Power Overhead Multiplier (ITac/ITdc)**
- **HVAC**
  - **IT total/HVAC total**
  - **Fan watts/cfm**
  - **Pump watts/gpm**
  - **Chiller plant (or chiller or overall HVAC) kW/ton**
- **Lighting watts/square foot**
- **ANCIS: Rack cooling index (fraction of IT within recommended temperature range)**
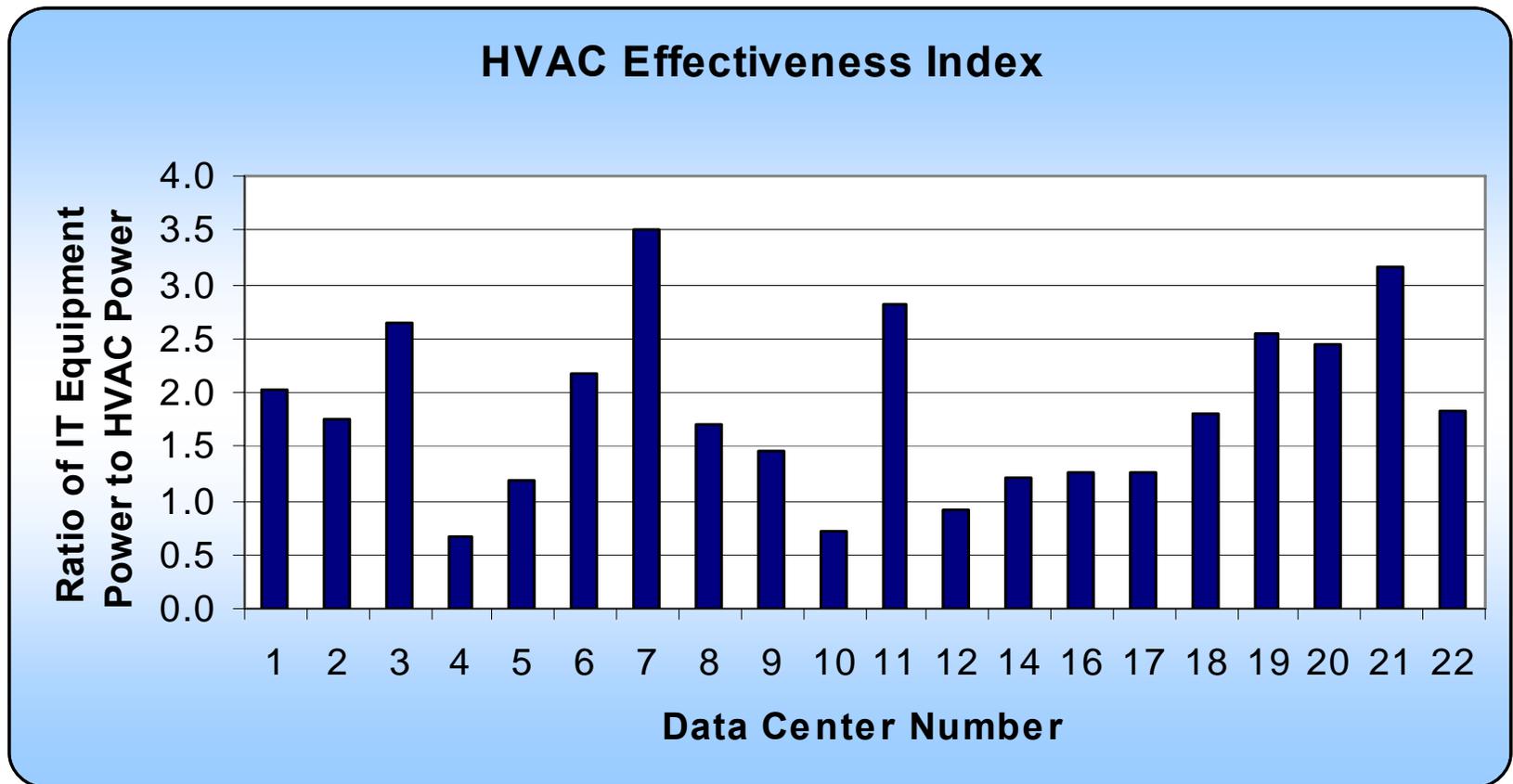- **ANCIS: Return temperature index (RAT-SAT)/ITΔT**
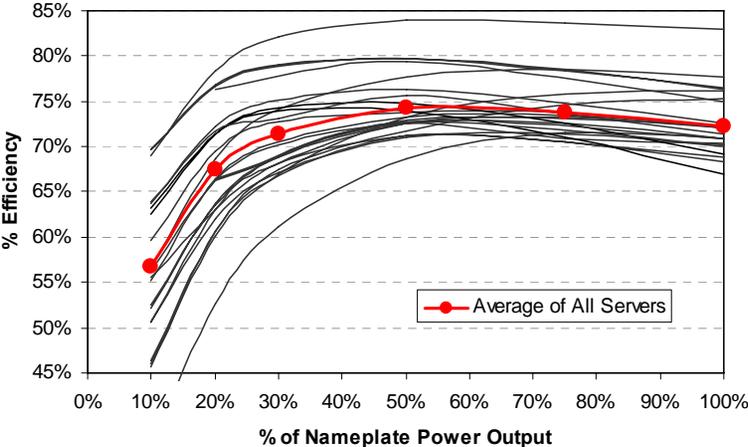
IT equipment load density

IT Equipment Load Intensity

2005 Benchmarks Ave. ~ 52

2003 Benchmarks Ave. ~ 25

Watts/sq. ft.

Data Center Number

We observed a wide variation in HVAC performance

HVAC Effectiveness Index

Power supplies in IT equipment generate much of the heat. Highly efficient supplies can reduce IT equipment load by 15% or more.

UPS efficiency also varies a lot.

(Do they need the same environment as the IT equipment or can their conditions be relaxed?)

Factory Measurements of UPS Efficiency
(tested using linear loads)
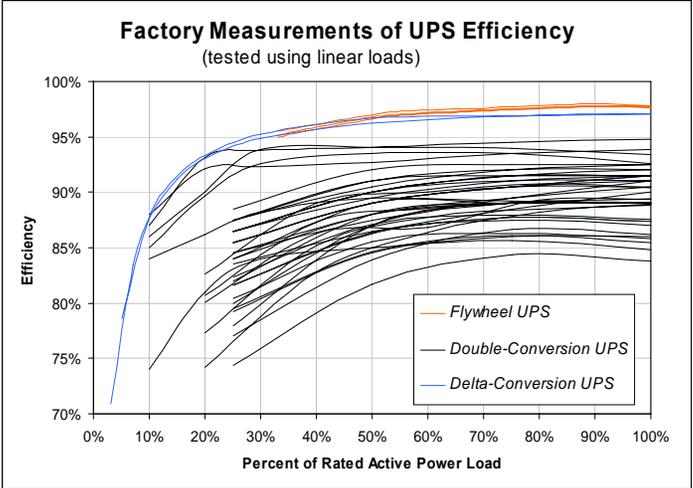
Summary of Opportunities for Energy Efficiency

- **Air management**
- **Right-sizing**
- **Central plant optimization**
- **Efficient air handling**
- **Free cooling**
- **Humidity control**
- **UPSs and power supplies**
- **On-site generation**
- **Liquid cooling**
- **Design and M&O processes**

Benchmarking for Energy Performance Improvement

Energy benchmarking can be effective in helping to identify better performing designs and strategies. As new strategies are implemented (e.g. liquid cooling), energy benchmarking will enable comparison of performance.

Options:

- **Rating system for new data centers based on design criteria**

- **Recognition program for upper quartile energy efficient performance for existing data centers**

- **Performance label for existing data centers, with requirement for continuous improvement**

Rating system based on design criteria

- **Model: LEED-New Construction**
- **Labs21 developed a LEED-based rating system for laboratories – basis for proposed LEED for Labs**
- **LBNL is working with the California Energy Commission on creating credits for data centers**
- **Principle focus on energy efficiency**
- **Secondary focus on site, materials, water, indoor environment**
- **Must achieve a minimum number of points to be certified**
- **Documentation required for each point**
- **Additional levels of achievement possible**
- **Does not address post-construction performance**

Recognition program for energy efficient performance

- **Model: ENERGY STAR for Buildings**
- **Would need statistical model for existing data centers that included process as well as building performance**
- **Exclusive focus on energy efficiency**
- **Performance rating of ≥75 points on a scale of 1-100 based on statistical data**
- **Application requires**
  - **Company to benchmark itself against performance index**
  - **Professional engineer verifies and prepares statement of performance**
- **Label is good for one year**
- **Reapplication required to maintain ENERGY STAR**

Performance label for continuous improvement

- **Model: Facility certification for energy efficiency**
- **Under development for industrial plants- 2009 pilot**
- **Model suitable for existing data centers**
- **Comprehensive for processes and building**
- **Exclusive focus on energy efficiency**
- **Certification requires:**
  — **Compliance with energy management standard**
  — **Minimum implementation of recommendations that meet company IRR**
  — **5% energy intensity reduction over 2 years**
  — **Verification of energy savings required**
- **Re-certification every 3 years; 7.5% energy intensity reduction requirement**