U.S. Department of Energy
Energy Efficiency and Renewable Energy

Save ENERGY Now

FEMP

Data Center Assessments to Identify Efficiency Opportunities
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Outline

- Overview of opportunity
- Benchmark results
- Save Energy Now
- DC Pro Assessment tools
- Test drive DC Pro on line
- Other resources

Data Centers are INFORMATION FACTORIES…

- Data centers are energy intensive facilities
  - Server racks now designed for more than 25+ kW
  - Surging demand for data storage
  - Typical facility ~ 1MW, can be > 20 MW
  - Nationally 1.5% of US Electricity consumption in 2006
    - Projected to double in next 5 years
- Significant data center building boom
  - Power and cooling constraints in existing facilities

The rising cost of ownership

- Cost of electricity for computing and supporting infrastructure now surpassing capital cost of the IT equipment

  "Will utilities give away supercomputers with agreement for long term power contracts?"

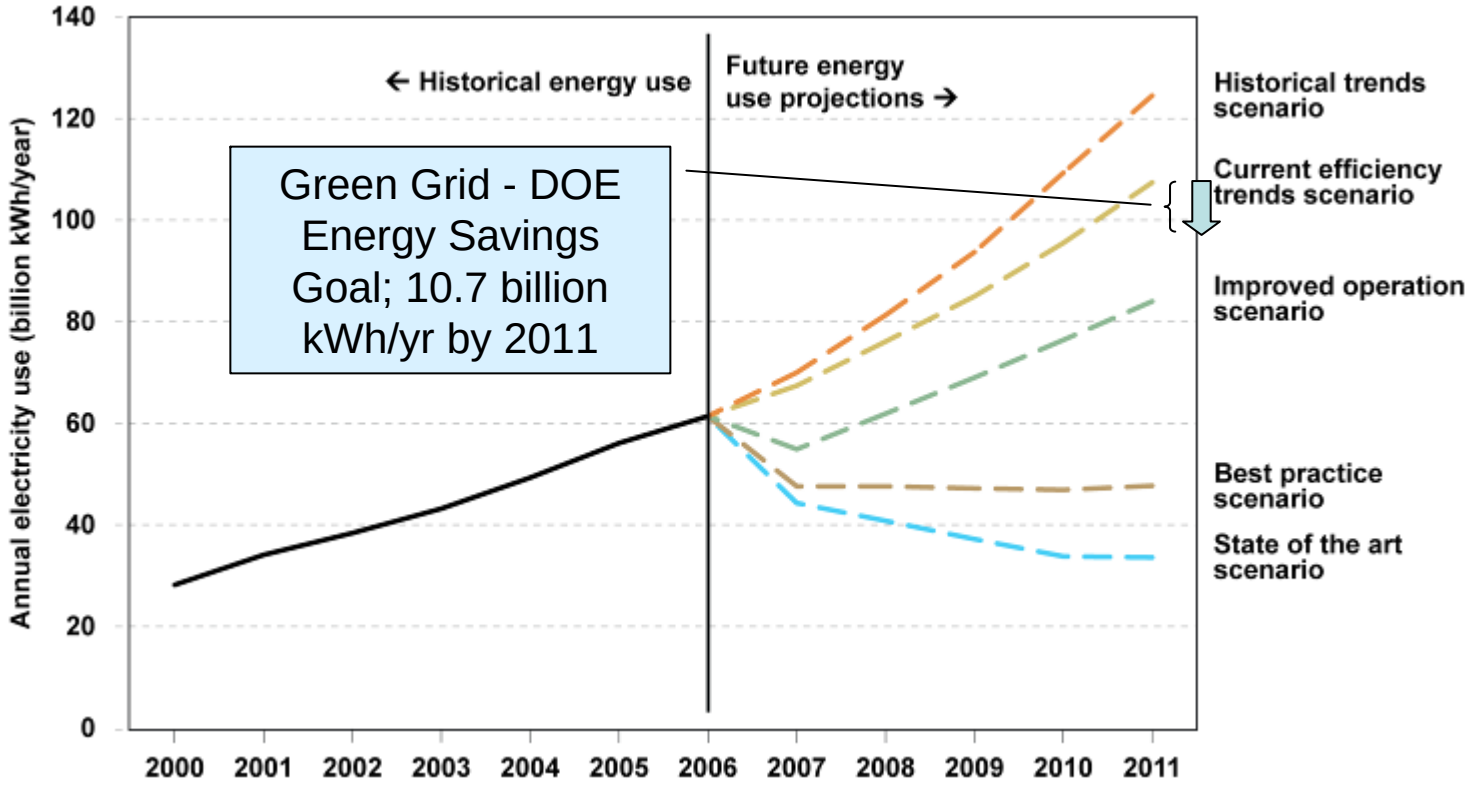
- Dis-incentives -- IT and facilities budgets are controlled in different parts of the organization

Source: The Uptime Institute, 2007

DOE-Green Grid partnership goals

2011 goal is 10% energy savings overall in U.S. data center

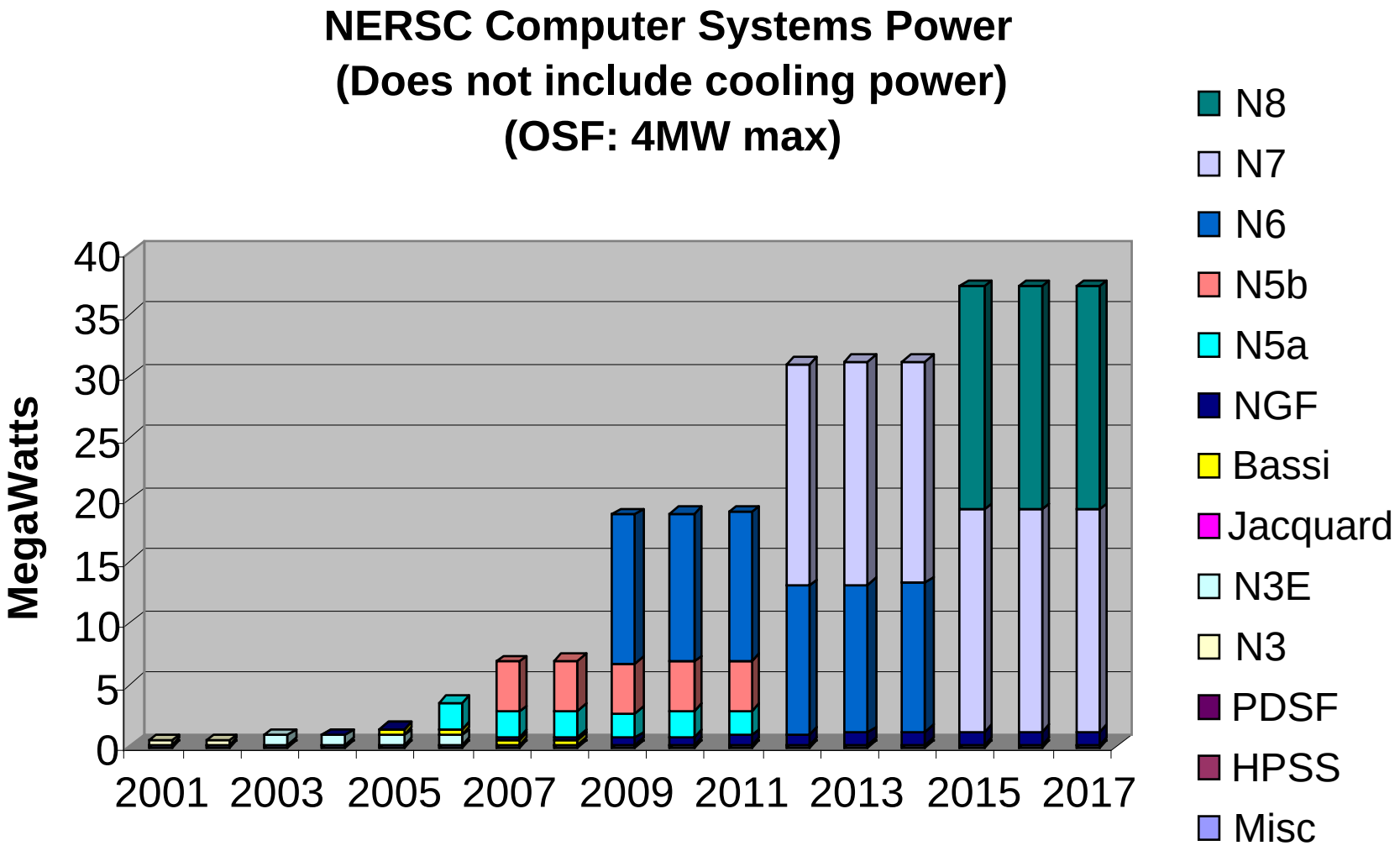
- 10.7 billion kWh
- Equivalent to electricity consumed by 1 million typical U.S. households
- Reduces greenhouse gas emissions by 6.5 million metrics tons of CO_2 per year



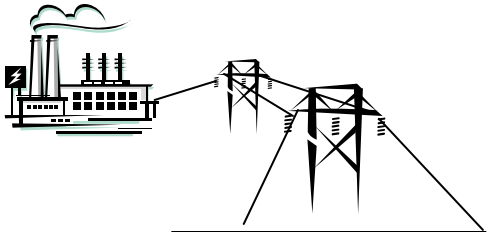
Potential energy savings

- 20-40% savings are typically possible
- Aggressive strategies – better than 50% savings
- Paybacks are short – 1 to 3 years are common
- Potential to extend life and capacity of existing data center infrastructure but this also could allow for more IT equip – raising total energy use
- Most don't know if their center is good or bad

LBNL super computer systems power:



Energy efficiency opportunities are everywhere



- Load management
- Server innovation

- Better air management
- Better environmental conditions
- Move to liquid cooling
- Optimized chilled-water plants
- Use of free cooling

Power Conversion & Distribution

Server Load/ Computing Operations

Cooling Equipment

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

Alternative Power Generation

- On-site generation
- Waste heat for cooling
- Use of renewable energy/fuel cells

Data center efficiency opportunities

Benchmarking over 30 centers consistently lead to opportunities

No silver bullet

Lots of silver bb's

Many areas for improvement…

Cooling

- Air Management
- Free Cooling – air or water
- Environmental conditions
- Centralized Air Handlers
- Low Pressure Drop Systems
- Fan Efficiency
- Cooling Plant Optimization
- Direct Liquid Cooling
- Right sizing/redundancy
- Heat recovery
- Building envelope

Electrical

- UPS and transformer efficiency
- High voltage distribution
- Premium efficiency motors
- Use of DC power
- Standby generation
- Right sizing/redundancy
- Lighting – efficiency and controls
- On-site generation

IT

- Power supply efficiency
- Standby/sleep power modes
- IT equipment fans
- Virtualization
- Load shifting

How can I improve efficiency in my center?

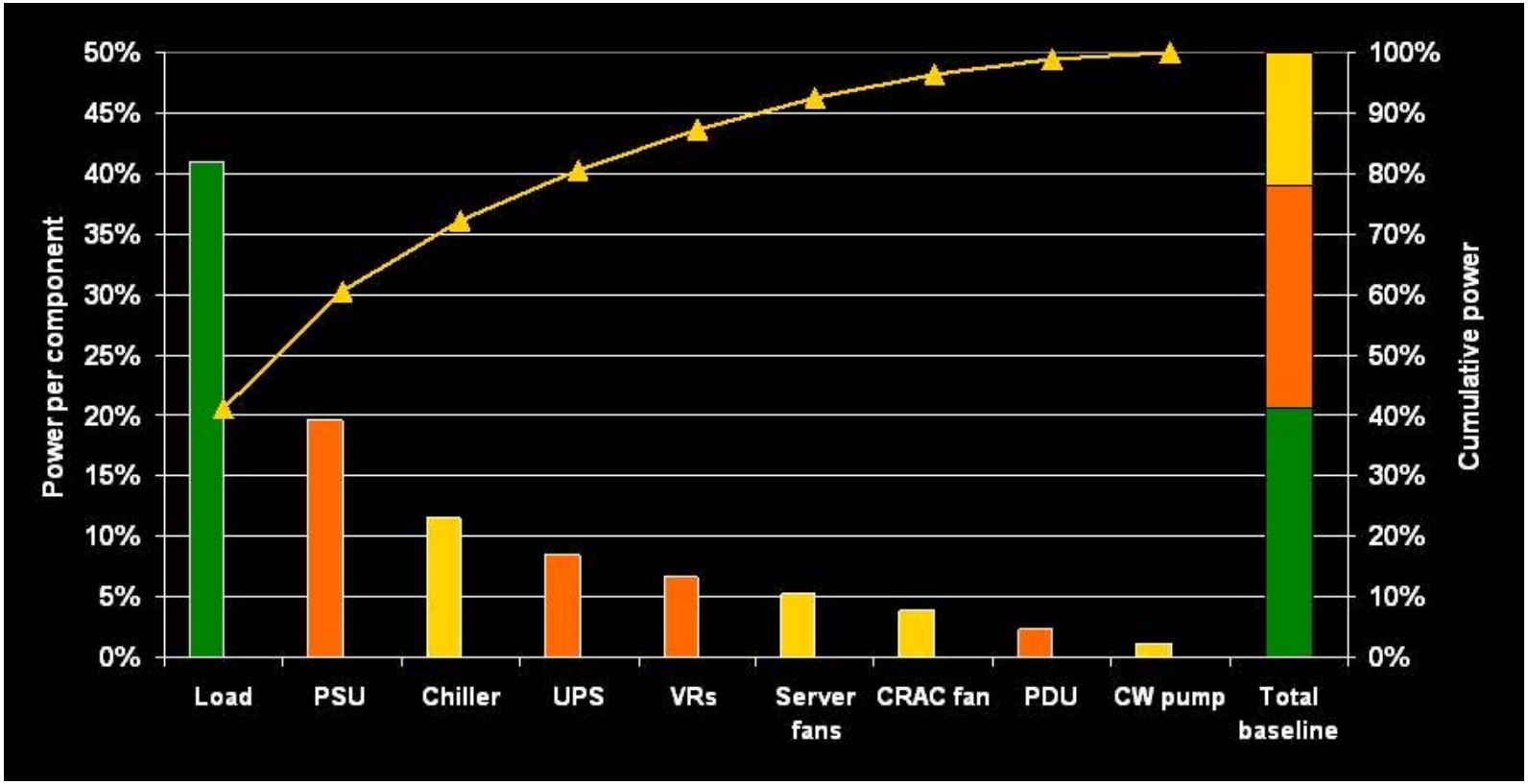
- Benchmarking – find the range of performance
- Assess performance of systems and components in your center
- Use benchmarking to help identify efficiency opportunities
- Study the costs and benefits of improvements
- Implement measures
- Monitor improvements and look for opportunities for continual improvement

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.

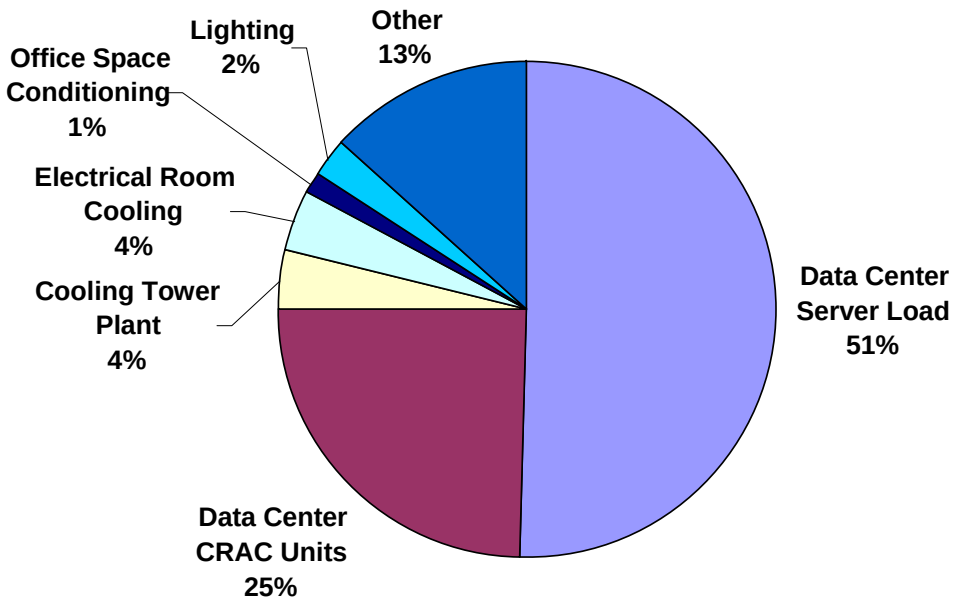
Electrical end use in one center

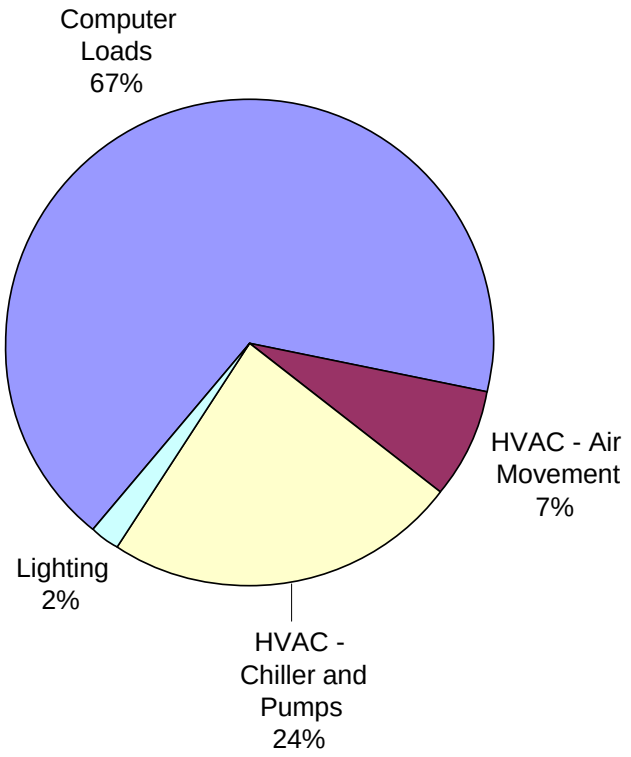


Courtesy of Michael Patterson, Intel Corporation

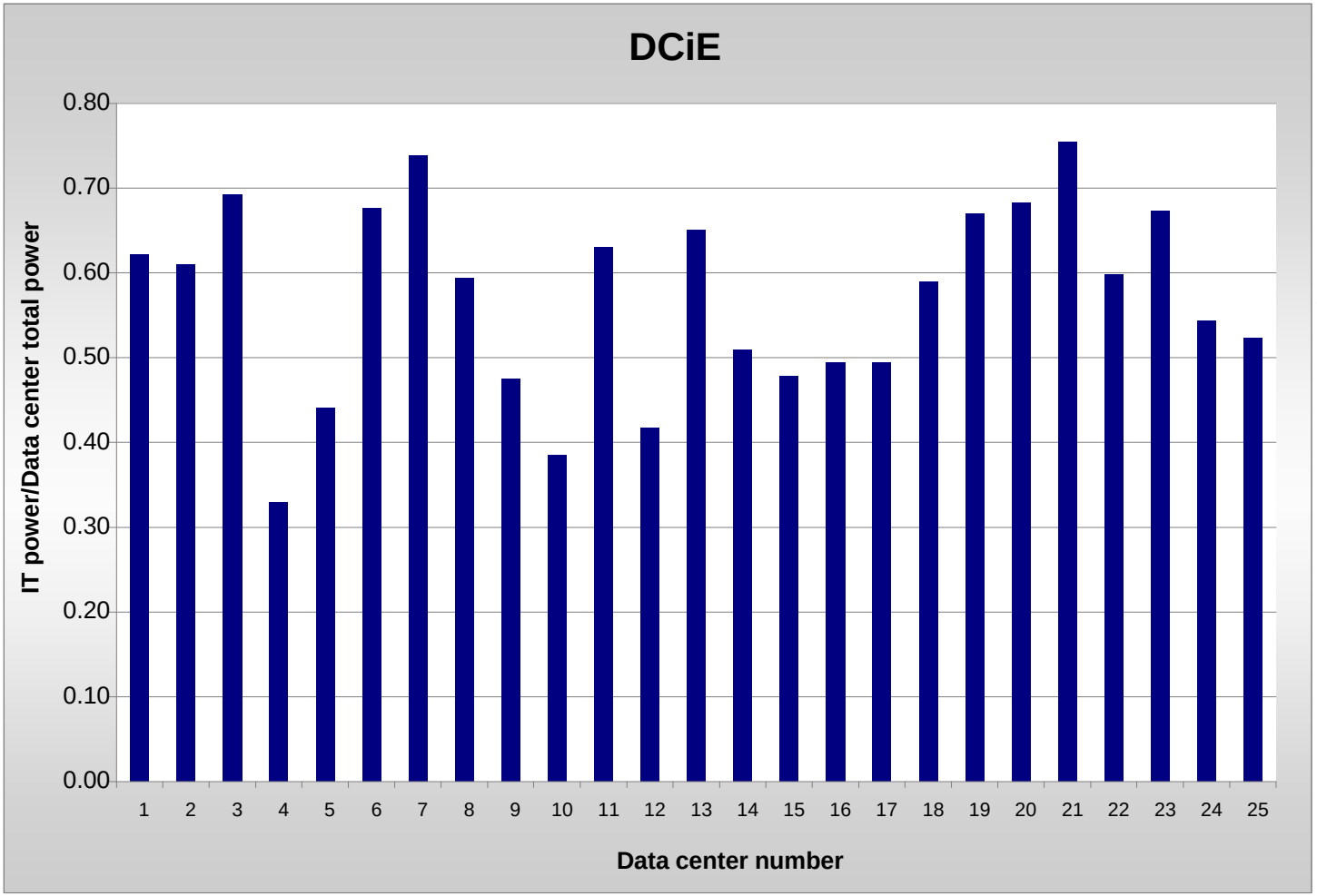
Your mileage will vary

The relative percentages of the energy doing computing varied considerably.





High level metric — IT/total



Average .57

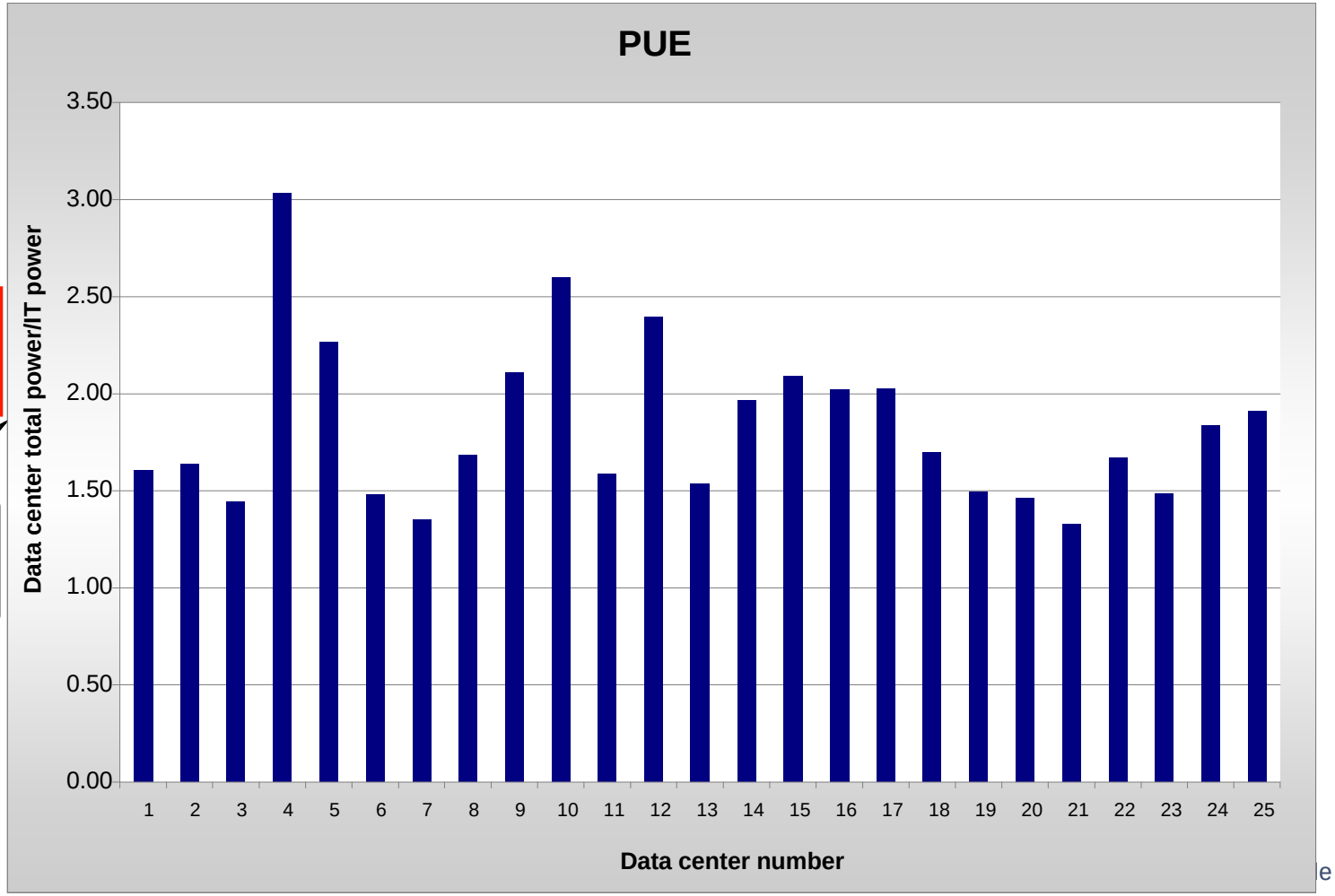
Higher is better

Source: LBNL

Inverse metric —total/IT (PUE)

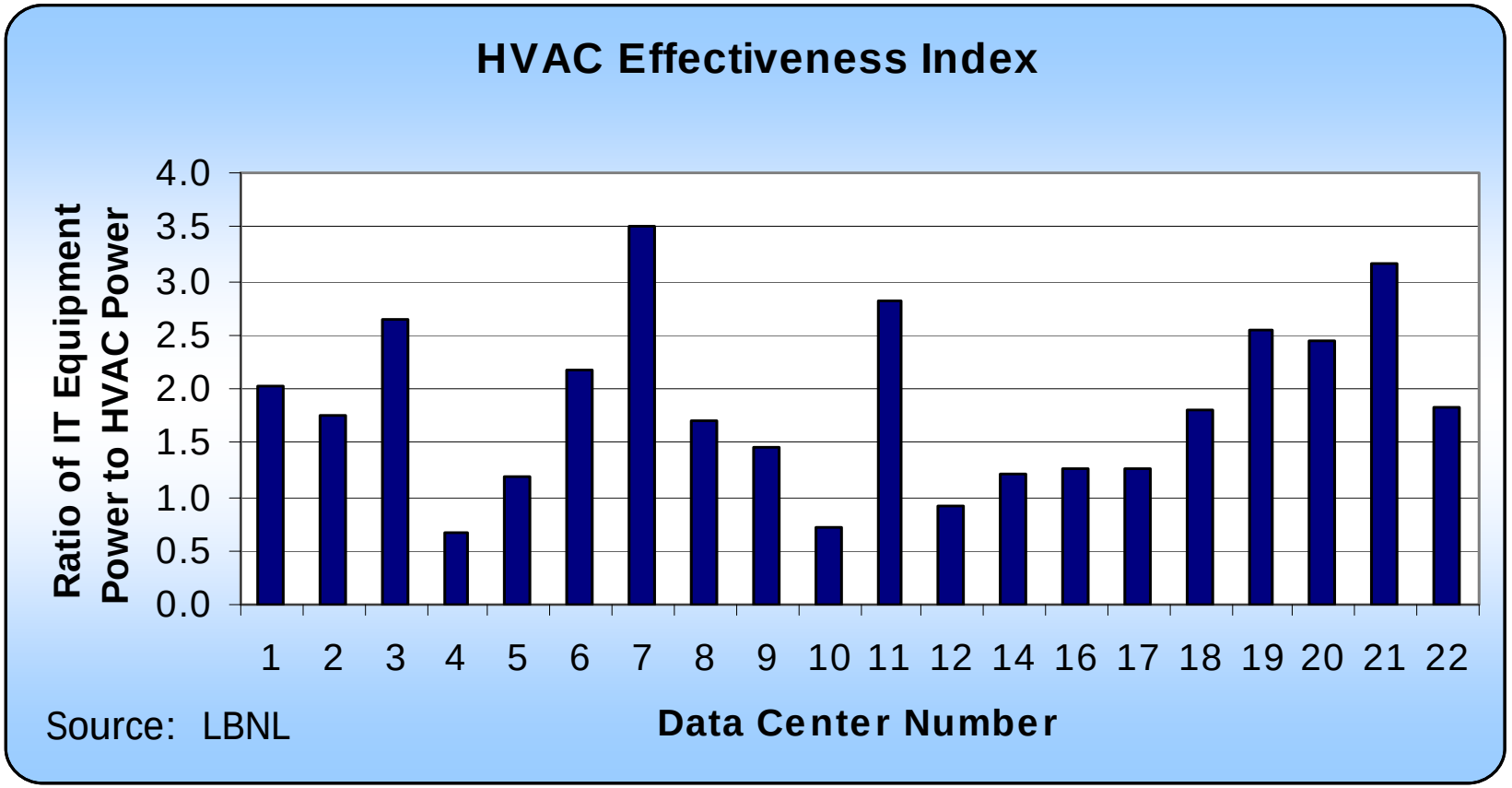
Average 1.83

Lower is better



HVAC system effectiveness

We observed a wide variation in HVAC performance



Save Energy Now – Data Center activities

- Data Center assessment tool suite – "DC Pro"
- Awareness training – DOE, ASHRAE, Green Grid
- Qualified specialist program
- Certification – continuous improvement
- With FEMP – improve Federal data centers
- Collaboration with industry associations:
  - Green Grid
  - ASHRAE
  - Uptime
  - Silicon Valley Leadership Group
  - others

DC Pro tool suite

- Profiling Tool: profiling and tracking
  - Establish DCiE baseline and efficiency potential (few hours effort)
  - Document actions taken
  - Track progress in DCiE over time
- Assessment tools: more in-depth site assessments
  - Suite of tools to address major sub-systems
  - Provides estimated savings for efficiency actions
  - ~2 week effort (including site visit)

DC Pro tools

High Level Profiling Tool

- Overall energy performance (baseline) of data center
- Performance of systems (infrastructure & IT) compared to benchmarks
- Prioritized list of energy efficiency actions and their savings, in terms of energy cost ($), source energy (Btu), and carbon emissions (Mtons)
- Points to more detailed system tools

IT Module
- Servers
- Storage & networking
- Software

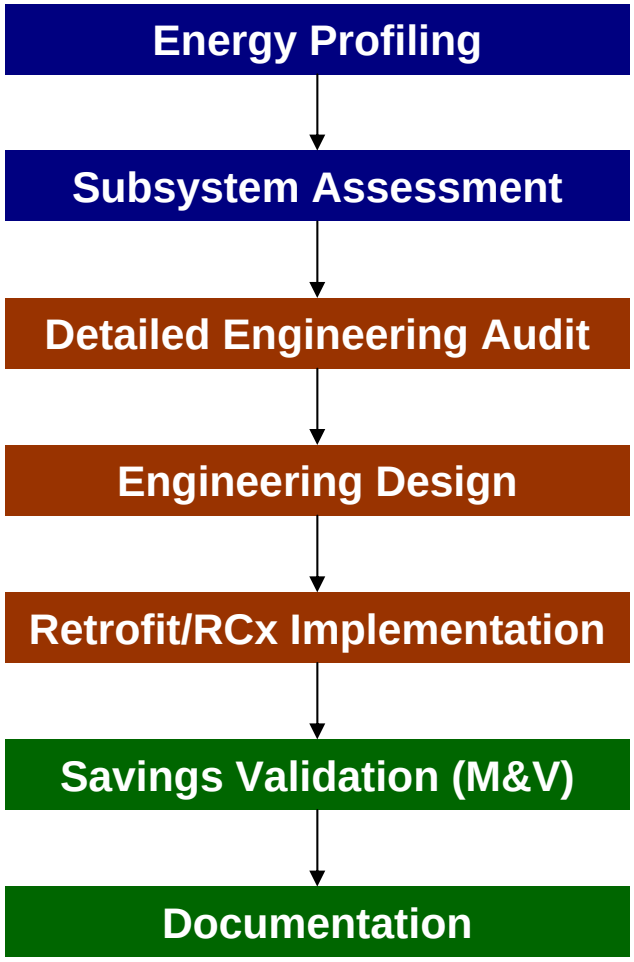
Cooling
- Air handlers/ conditioners
- Chillers, pumps, fans
- Free cooling

Air Management
- hot cold separation
- environmental conditions

Power Systems
- UPS
- PDU
- Transformers
- Lighting
- Standby gen.

On-Site Gen
- Renewables
- use of waste heat

Steps to saving energy:



- Assessments conducted by owners and engineering firms using DOE tools
- Tools provide uniform metrics and approach
- Raises awareness of opportunities

- Audits, design and implementation by engineering firms and contractors

- M&V by site personnel and eng firms
- DC Pro can document results, and track performance improvements
- Further best practices can be identified

Getting started with an assessment

Visit:

http://hightech.lbl.gov/dc-assessment-tools.html

- Assessment process description
- Assessment worksheet
- Standard report template
- Master list of actions
- Link to DC Pro profiling tool
- Electrical systems tool (Beta spreadsheet version)

Worksheet Sample

CRAC and AHU							
A1	Actual Intake Temperature Range	F					Representative sample (measured values)
A2	Actual Intake Humidity Range	% RH					Representative sample (measured values)
A3	Recommended Temp Ranges	F					Obtain from company standard
A4	Allowable Temp Ranges	F					Obtain from company standard
A5	Average Heat Density (elec active)	W/sqft					Based on P1 and G1
A6	Maximum Heat Density (elec active)	W/sqft					Based on P2 and G1
A7	Floor Plenum Static Pressure	in of water					Representative sample (measured values)
A8	Floor Leakage	%					Base on total rack flow and total system flow
A9	CRAC Power	kW					
A10	CRAC Airflow	cfm					Use TAB report or design data if measured airfl unavailable
A11	Average Return Air Temperature	F					Measured values, not setpoints
A12	Average Supply Air Temperature	F					Measured values, not setpoints
A13	Entering Absolute Humidity	lbs					
A14	Leaving Absolute Humidity	lbs					
A15	Average Rack Temperature Rise	F					Representative sample (measured values)
A16	Rack Intake Temperatures	F					Representative sample (measured values)
A17	Rack Exhaust Temperatures	F					Representative sample (measured values)

DC Pro profiling tool demonstration

www.eere.energy.gov/datacenters

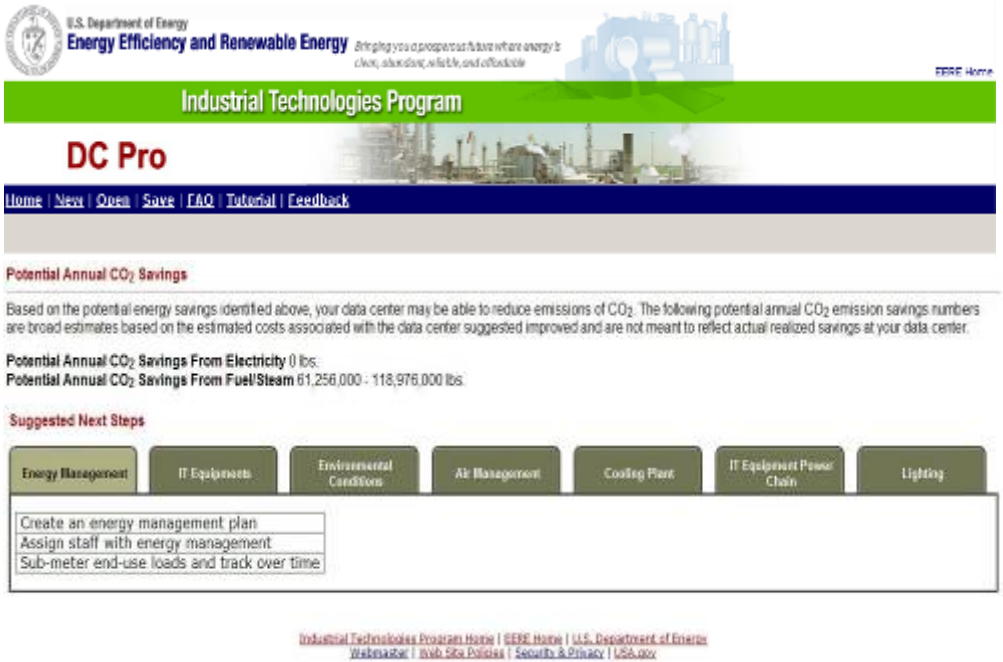
DC Pro electrical tool demonstration

http://hightech.lbl.gov/dc-assessment-tools.html

Example "DC Pro" recommendations

List of Actions (for Electric Distribution System)

- Avoid lightly loaded UPS systems
- Use high efficiency MV and LV transformers
- Reduce the number of transformers upstream and downstream of the UPS
- Locate transformers outside the data center
- Use 480 V instead of 208 V static switches (STS)
- Specify high-efficiency power supplies
- Eliminate redundant power supplies
- Supply DC voltage to IT rack



Tool development status and outlook

Currently Available:

- High level profiling tool — v 1.0
- Electrical assessment tool — Beta

Future Assessment Tools:

- Electrical module — (initial issue)
- Air management module — (December 08)
- Cooling module — (TBD depends upon utility funding)
- IT module — (February 09 – Green Grid input June 09 Beta version)
- On-site Generation — (TBD)

Links to get started

DOE Website: Sign up to stay up to date on new developments
www.eere.energy.gov/datacenters

Lawrence Berkeley National Laboratory (LBNL)
http://hightech.lbl.gov/datacenters/

ASHRAE Data Center technical guidebooks
http://tc99.ashraetcs.org/

The Green Grid Association: White papers
http://www.thegreengrid.org/gg_content/

Energy Star® Program
http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency

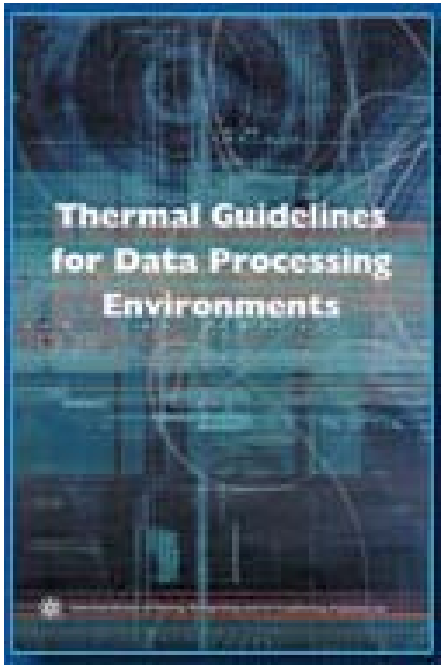
Uptime Institute white papers
www.uptimeinstitute.org

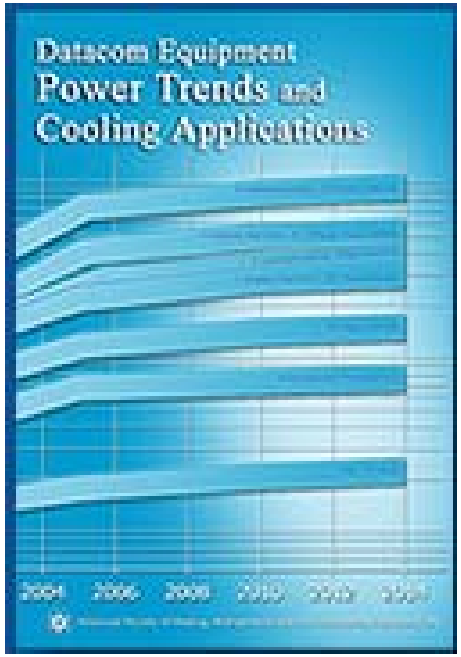
Web based training resource

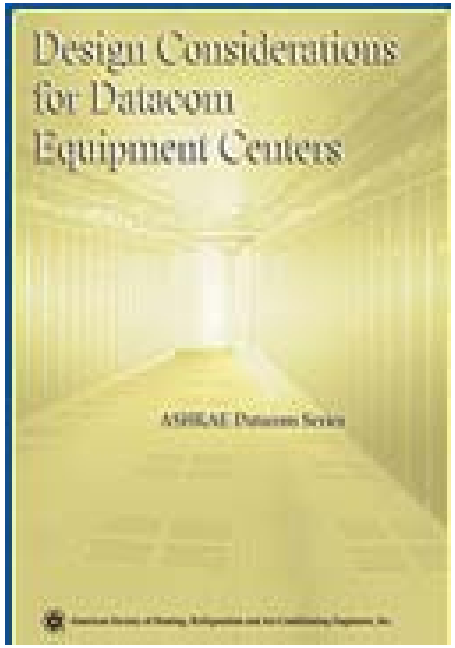
http://hightech.lbl.gov/dctraining/TOP.html

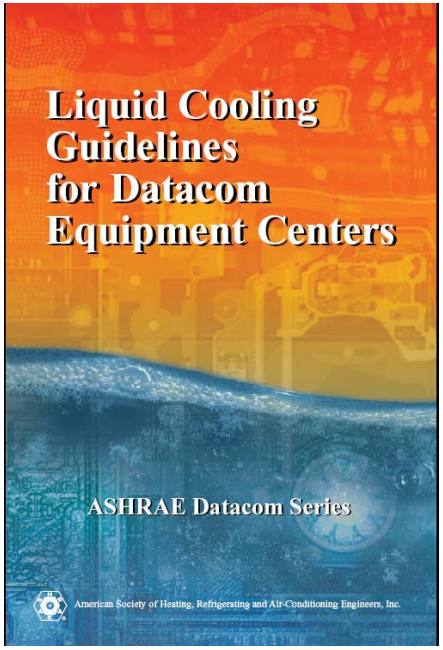
ASHRAE guidelines

six books published—more in preparation









ASHRAE, Thermal Guidelines for Data Processing Environments, 2004, Datacom Equipment Power Trends and Cooling Applications, 2005, Design Considerations for Datacom Equipment Centers, 2005, Liquid Cooling Guidelines for Datacom Equipment Centers, 2006, © American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., www.ashrae.org