Data center power use: a review of the historical data

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Background

- Continued controversy over how much power is used by computers and data centers in particular (see http://enduse.lbl.gov/Projects/InfoTech.html)
- Many claims of 100, 200, 300 Watts/square foot for planned data center facilities circa 1999-2001
- Are these numbers representative of hosting facilities generally?
- Are they representative of corporate data centers?

Data Sources for power densities

- Mitchell Jackson 2001–same facility revisited (2003)
- LBNL Benchmarking results
- Uptime Institute

Data center in Bay Area--Mitchell Jackson 2001, revisited in 2003

- Detailed assessment of a single facility in 2001 (we had complete access)
- Revisited same facility in 2003
  - Data center floor area up 33%
  - Total computer power density (W/sf) up 13%
  - Total computer room power density (in W/sf, including HVAC and auxiliaries) constant 2001 to 2003
- Removing unneccessary lighting and CRAC units and HVAC adjustments led to significant savings

Data center in Bay Area: Power densities

Term	Definition	2001 Power use Watts/sf	2003 Power use Watts/sf
Computer Power Density	Power drawn by the computer equipment (in watts) divided by the computer room floor area (in square feet)	16	18
Total Computer Room Power Density	Power drawn by the computer equipment and all of the supporting equipment such as PDUs, UPSs, HVAC, and lights (in watts) divided by the computer room floor area (in square feet)	33	33
Building Power Density	Total power drawn by the building (in watts) divided by the total floor area of the building (in square feet)	11	13

Data center in Bay Area: More on power densities

	Mitchell-Jackson 2001	Current study 2003	2003/ 2001
Computer Room Floor area (ft^2)	27,500	36,500	*1.33*
Computer Power Load (kW)	432	669	*1.55*
Lighting (kW)	117	59	*0.50*
Central Chiller Plant (kW)	213	275	*1.29*
Fans, CRACs, AHUs, etc (kW)	250	178	*0.71*
Total Building Lighting Density (W/ft^2)	0.90	0.50	*0.56*
Total Building Chiller Plant Density (W/ft^2)	1.70	2.20	*1.29*
Total Building Fans/CRACs/AHUs Density (W/ft^2)	2.00	1.40	*0.70*

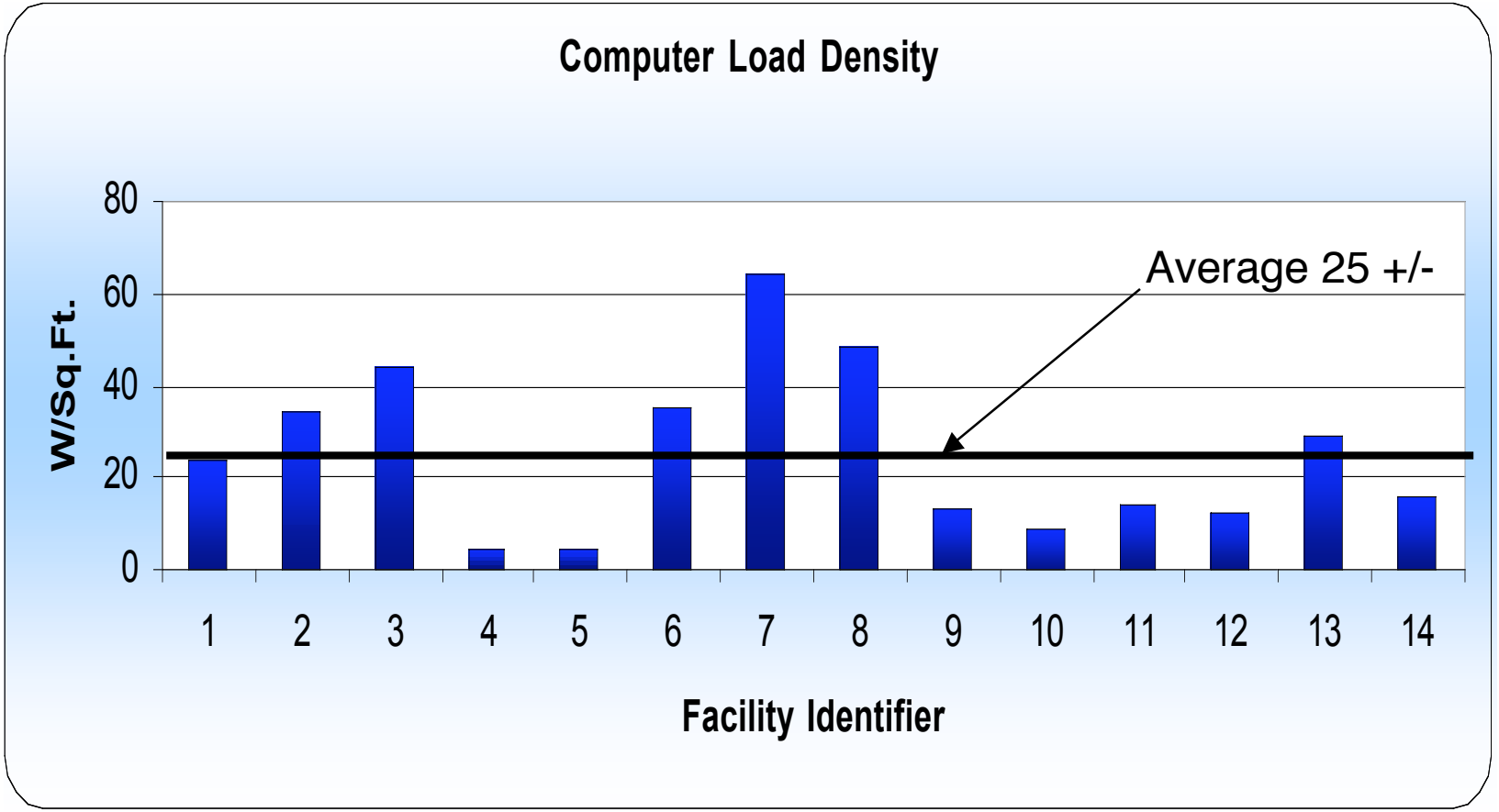
Source for 2003 data: Blazek, Michele, Huimin Chong, Woonsien Loh, and Jonathan Koomey. 2004. "A data center revisited: Assessment of the energy impacts of retrofits and technology trends in a high-density computing facility." *Forthcoming in a special issue of the ASCE Journal of Infrastructure Systems*. January.
Source for 2001 data: Mitchell-Jackson, Jennifer, Jonathan Koomey, Bruce Nordman, and Michele Blazek. 2003. "Data Center Power Requirements: Measurements From Silicon Valley." *Energy–The International Journal (also LBNL-48554)*. vol. 28, no. 8. June. pp. 837 - 850.

LBNL Case Studies

- 14 Data centers in California and New York
- Detailed metering and analysis of facilities
- Led by Bill Tschudi and Dale Sartor of LBNL

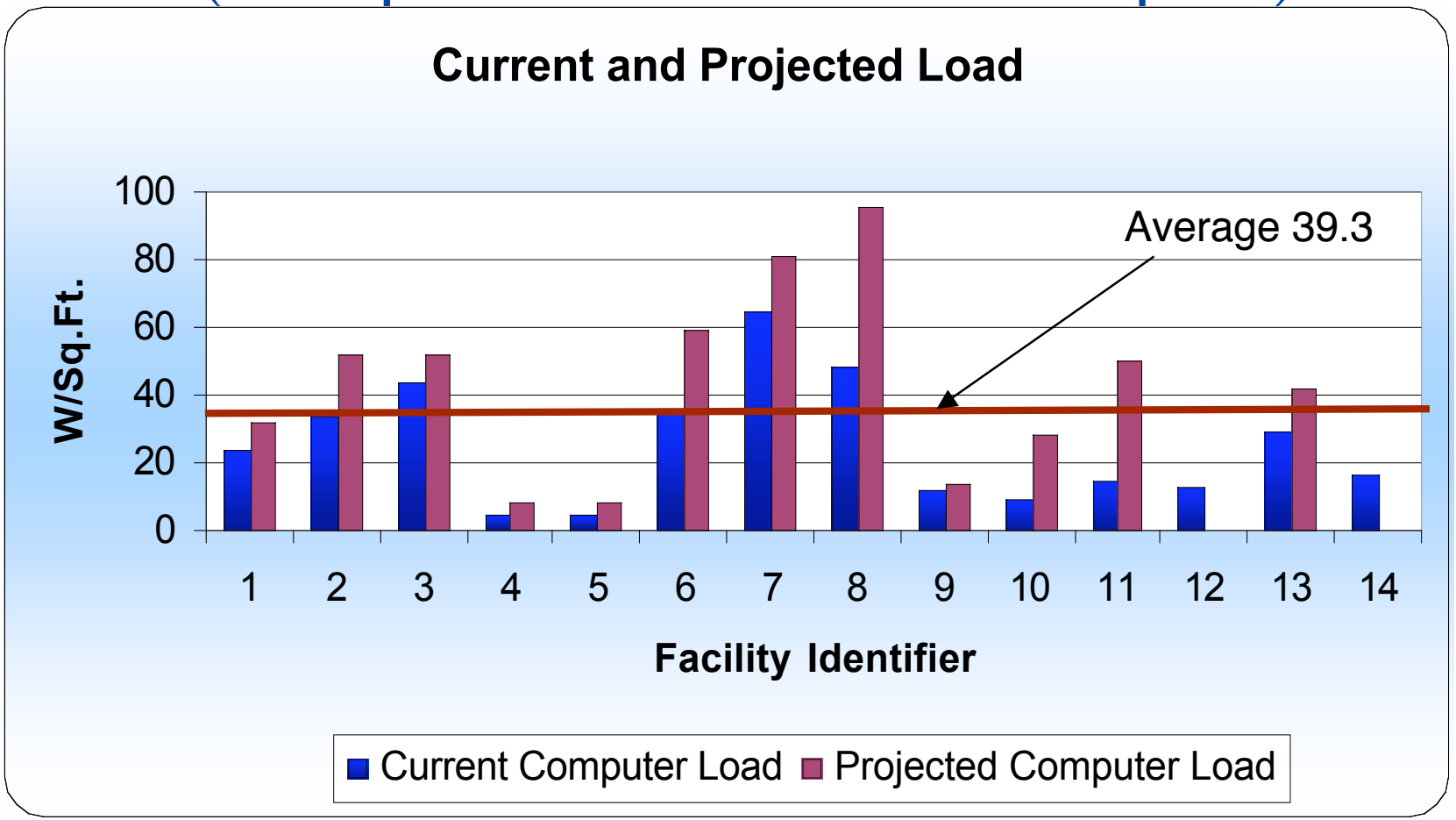
LBNL: Actual Computer Loads

(W/Sq.Ft. of data center floor space)

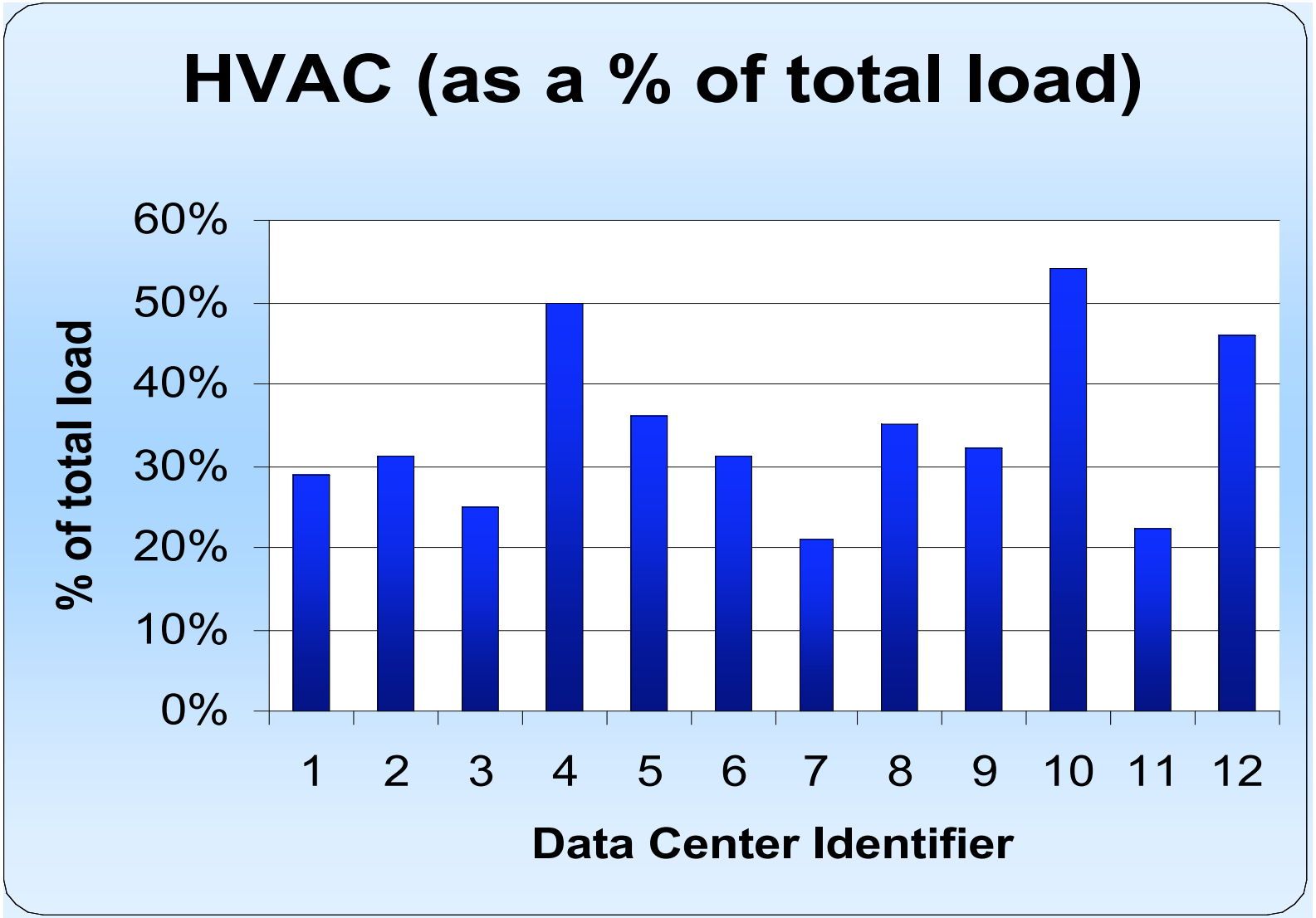


LBNL: Projected Computer Loads

(W/Sq.Ft. of data center floor space)



HVAC (as a % of total load)



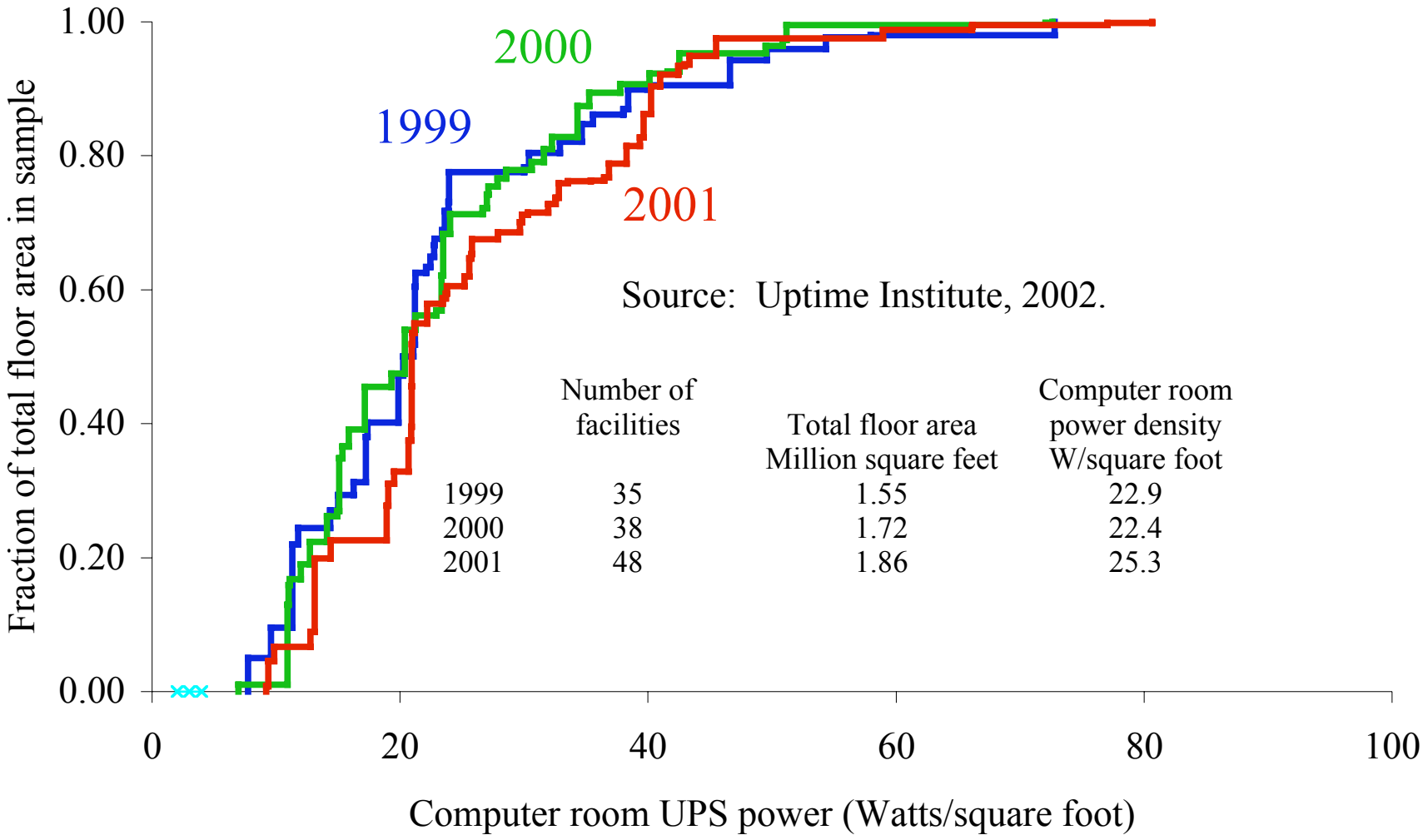
Methods: Uptime Institute Data

- Obtain data from Site Uptime Network data on a confidential basis
- Analyze responses to Network quarterly profile questionnaires for 1999, 2000, and 2001
- Focus on UPS power and electrically active (net) floor area in square feet (sf)
- Clean data, eliminating inconsistencies in reporting, typos, and other problems
- Summarize data in averages and in cumulative distributions

Results : Uptime Institute Data

- Distributions don't differ much over the three year analysis period
- Minimum computer room power densities are 8-10 W/sf, maximums are 70-80 W/sf, avg is 22-25 W/sf
- To get total loads (HVAC & auxiliaries plus electrically active floor area power use) multiply by about 2, yielding average total power densities of roughly 50 W/sf (comparable to previous estimates)
- No obvious time trends in the data, either in the aggregate or when examined by facility

Distribution of Computer Room Power Used by Site Uptime Network Data Centers



Source: Uptime Institute, 2002.

	Number of facilities	Total floor area Million square feet	Computer room power density W/square foot
1999	35	1.55	22.9
2000	38	1.72	22.4
2001	48	1.86	25.3

Summary: Uptime Institute Data

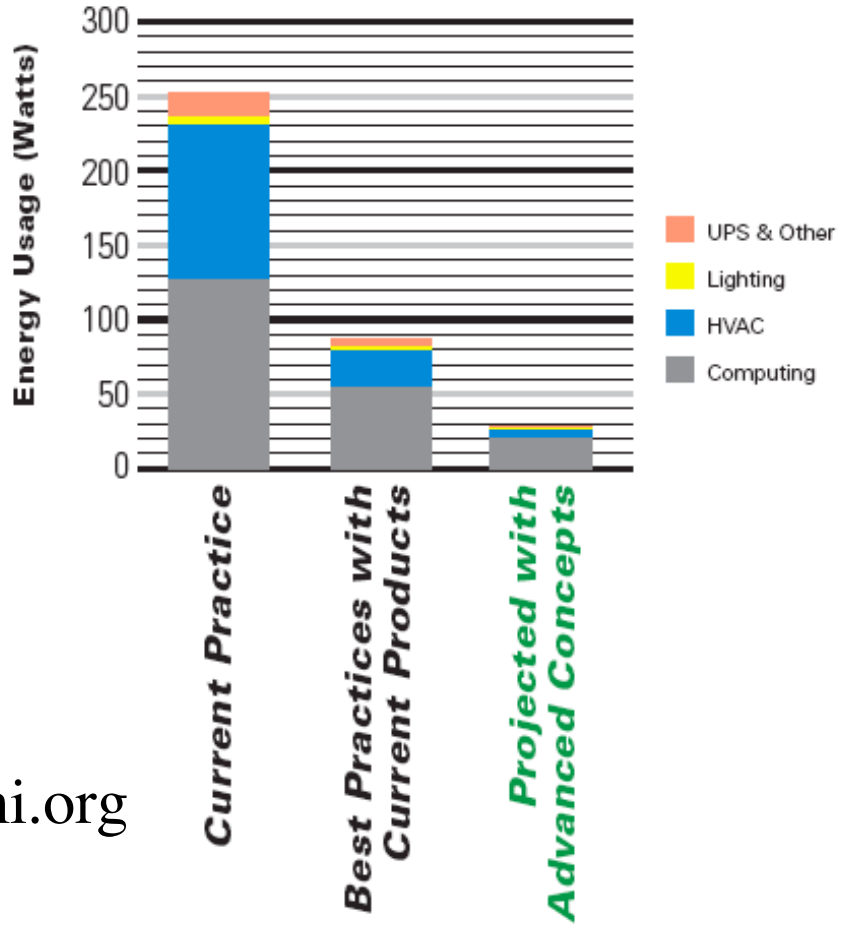
- On average, Network facilities show computer room power densities (electrically-active floor area) of 22-25 W/sf (total power densities ~ 50 W/sf, consistent with earlier work)
- Maximum computer power density in sample is 70-80W/sf, minimum is 8-10 W/sf
- Sample size not enough to determine time trends or to draw conclusions by industry type
- More work needed to estimate total data center floor area in the US and total power demands

Efficiency opportunities

- Lighting
- HVAC
- Servers
  - Power supplies (some now only 50% efficient)
  - Dynamic processor power management using voltage and frequency scaling (e.g., IBM Power PC 405 LP, Transmeta)
- Optimization at any point in the design process fails to account for whole system effects (e.g. servers)
- Need to align incentives (charge per kW of power demanded in data center facilities, not per square ft)

Efficiency opportunities: RMI Charrette results (Feb 2003)

- The charrette resulted in 62 design recommendations that can reduce data center energy demand by 89 percent compared with today's standard designs, while providing
  - –equivalent computing power
  - –lower system capital cost
  - –faster construction
  - –greatly improved reliability



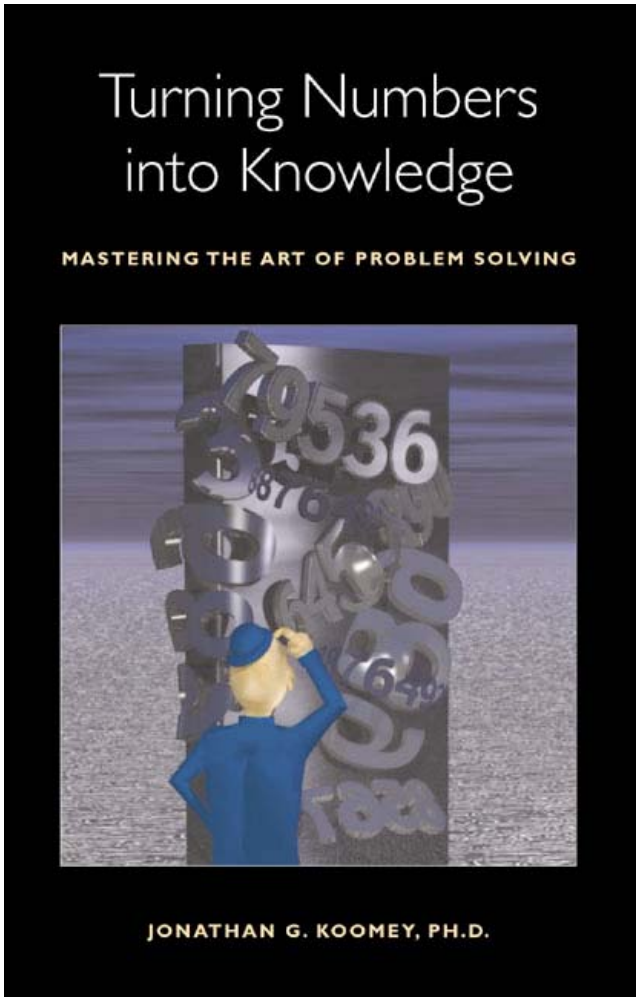
For details, see http://www.rmi.org

Conclusions

- Typical data center computer power densities are roughly 25 W/sf, implying total computer room power densities of roughly 50 W/sf
- Few isolated examples of computer power densities greater than 80 W/sf
- Not clear that expectations of much higher power densities will come to pass
  - Plenty of empty space to spread out servers
  - Large efficiency opportunities
- We need more data!

New IBM Class: Getting the numbers right

http://www.numbersintoknowledge.com



Training class in compiling, analyzing, and presenting numbers for effective decision making to be taught at the IBM Performance Testing Center in San Jose, CA March 29-31, 2004. Course will be generally available throughout IBM after that.