ESTIMATING TOTAL POWER USED BY DATA CENTERS IN CALIFORNIA

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INTRODUCTION

There are big uncertainties in estimating data center floor areas and associated electric loads. Four broad categories of data centers are of interest here:

(1) Multi-tenant hosting facilities, which include data centers owned by third parties that house servers owned by other companies (co-location), as well as data centers that sell server services to companies who do not want to manage their own servers (managed hosting). These facilities are often housed in buildings devoted solely to these activities, or in buildings associated with telecommunications and networking equipment.

(2) Corporate or enterprise data centers, owned by corporations and managed in-house. These data centers are often housed within existing facilities and may comprise only a small portion of the total floor area associated with those facilities.

(3) Institutional and government data centers—these facilities are owned and operated by Federal, state, and local governments or by non-profit institutions.

(4) Educational data centers serving students and faculty in post-secondary institutions.

This study estimates total power use for such facilities, focusing mainly on California. We begin by summarizing what is known about total floor area for these facilities, and then analyzing the power densities associated with this floor area. Total power use is then the total floor area times the power densities.

Unfortunately, there is little definitive work on aggregate floor areas of data center facilities in California (or elsewhere, for that matter). This study relies on back of the envelope calculations and on the data that do exist to assess the order of magnitude of this floor area. More research will surely be needed to fully understand the current and future floor stock of data centers in California—this report is only a first cut.

DEFINITIONS

Data center power requirements are also often misstated because of the lack of common metrics and terminology (Mitchell-Jackson et al. 2002, Mitchell-Jackson et al. 2003). Power densities for these facilities are often given in terms of watts per square foot (W/ft^2) or watts per square meter (W/m^2) but it is not always clear what such numbers mean. For example, a stated power density of 100 W/ft^2 could refer to the power drawn by an isolated rack of computer equipment or the average power density of the building.

Extrapolating the power requirements of a data center from an isolated rack is misleading because the floor area within a building includes office space, restrooms and hallways, all of which require much less power per square foot than does a computer rack.

Many estimates of total building floor area for data center facilities include significant amounts of space not critical to a data center's main function. In a data center facility, 15% to 75% of the building's area is usually designated for meeting rooms, offices, restrooms and hallways, but only the computer room floor area is relevant to assessments of the growth in electricity demand of data centers. Computer room floor area includes both the area under the racks of computer equipment and that of some common areas, such as the aisles between racks of computer equipment. It does not include office space, lobbies, bathrooms, space set aside for potential future expansion, or mechanical equipment rooms.

Because of the confusion over this issue, in our earlier work (Mitchell-Jackson et al. 2002, Mitchell-Jackson et al. 2003) we defined two key terms: *computer power density* is the power drawn by the computer equipment (in watts) divided by the computer room floor area (in square meters or square feet); *total computer room power density* is defined as the power drawn by the computer equipment and all of the supporting equipment such as power distribution units, uninterruptible power supplies, HVAC and lights (in watts) divided by the electrically active ("net") computer room floor area (in square meters or m^2). Total computer room power density is the most meaningful indicator of power needs, but computer power density can also be useful, as we shall see below. Both parameters can be compared between buildings of different sizes as well as between data centers at different stages of development.

Some in the industry (e.g. Ken Brill of the Uptime Institute) are beginning to focus on power/rack as a more convenient and accurate metric. This choice eliminates the confusion over area-based metrics.

ESTIMATING FLOOR AREA

Most of the data that exist relate to hosting facilities, because that is where the growth was during the Internet boom, and that is what consultants found profitable to track. While fairly accurate information already exists for total multi-tenant web hosting space, corporate, institutional, and educational data center floor areas are not currently tracked by any industry sources.[1] Because of this lack of published information, we contacted sources in the relevant sectors to get their institutional perspectives (their contact information is contained in Table 1). In all cases we focus on the so-called "net floor area" or "electrically active floor area" of the computer rooms in data center facilities.

[1] At the PG&E/7X24 Exchange workshop 0n April 17, 2003, some participants expressed opinions about the amount of data center floor area in California. Email was sent to those participants to obtain whatever data existed, but no participants supplied useful data. This experience reflects the sorry state of information on data center floor area—lots of people have opinions on the topic, but there's little real data.

Multi-tenant hosting facilities

Two comprehensive studies for data-center floor area for hosting facilities were published in August 2000 by Salomon Smith Barney (Mahedy et al. 2000) and in January 2001 by Robertson Stephens (Juarez et al. 2001). Each study surveyed about 60 companies and developed U.S. and global distributions of hosting-type data centers by number and by floor area. They also estimated floor-area growth for the near future. In April 2001 Salomon Smith Barney (Mahedy et al. 2001) revised their floor area estimations, reducing them on a global basis by about 25% (unfortunately the later SSB report did not split out California or US data centers, so more geographically detailed correction factors are not available). Table 2 summarizes the estimates and projections published by these two companies. There is good agreement between these sources—especially after the update of the SSB numbers in 2001-- on the global gross floor area and the split of the floor area between managed hosting and colocation.

Looking into the situation in California in more detail, SSB 2000 (Mahedy et al. 2000) and RS (Juarez et al. 2001) tracked the companies presented in Table 3. Table 3 also shows the number of locations of each company in the three major areas in California, namely, San Francisco/Bay Area, Los Angeles/San Diego, and Sacramento. RS tracked more locations compared to SSB (about twice as many). However, for the locations tracked by SSB 2000, very detailed information is available, including estimates of net and gross floor area.

The floor area data for the California SSB locations are presented in Table 4. We focus in particular on the end of year 2000 data, because that is the same year used by the RS report. First, the estimate of net floor area in California (1.14 Msf) needs to be adjusted downward by 25% to reflect the global correction estimated in the SSB 2001 report (this correction reflects the slowdown in the high tech industry that first began in early 2000). Next, the SSB data must be adjusted upwards by a factor of 2 to reflect the larger coverage of the RS report. These sequential calculations yield an estimate of 1.14 x 0.75 x 2 or 1.7 Msf as a lower bound estimate of the net floor area of hosting-type facilities in California. This calculation assumes that the high tech slowdown hit all regions equally, and that the additional coverage of the RS report over the SSB 2000 report is the same everywhere, and does not differ in California.

We know that even the RS report did not survey every relevant company in the hosting industry, but we expect that they captured the majority. This implies that roughly 2 Msf is a reasonable estimate for the net floor area of hosting-type facilities in California (with the understanding that this estimate is highly uncertain).

Corporate data centers

The uncertainty in total floor area is even greater for corporate than for hosting facilities, because details on corporate facilities are normally regarded as closely-held proprietary information. For this reason, no reliable data exist on corporate data center floor area in the aggregate. We rely instead on expert judgments to bound the range.

Our first attempt to estimate corporate data center floor area used total server shipments, estimates of equipment lifetimes, and typical floor areas associated with different types of equipment. Our second attempt involved estimating typical facility sizes by industry and estimating the percentage of firms of a given type that have in-house data centers. Time and budget constraints prevented us from conducting an exhaustive survey, so we assumed reasonable ranges by industry type and firm size and combined these estimates with California Census data to estimate total floor space. The projections generated by these two approaches were highly sensitive to the assumptions and as a result the range of possible projections was too large for us to have confidence in them. We therefore abandoned these approaches.

After being foiled in these initial attempts, we talked to several experts on this topic, most notably Ken Brill of the Uptime Institute and Ion Yadigaroglu of Koch Industries. We also asked some of the largest companies in the industry to supply us with their California floor areas, some of whom replied, some of whom didn't. After these discussions, we adopted a range of from 2 Msf to 4 Msf for corporate data center net floor area in California. This estimate is also highly uncertain.

Institutional and government data centers

Institutional facilities include those for non-profit organizations (including some hospitals). Government data centers include facilities at the Federal, state, county, and city levels. Unfortunately, we were only able to locate credible data at the state government level. Federal space operated by such organizations as the U.S. Air Force, DOE, FBI, CDC, and several others is difficult to inventory due to lack of centralized information and heightened security concerns.

State government data center space is largely concentrated within three large facilities all with active floor space in excess of 40,000 Sq. Ft. as well as several second tier data centers. According to State data center managers, larger cities within California each run their own data center, as well as larger counties. As an example, the County of Marin currently operates a 1850 sq. ft. data center for county related government purposes.

Table 5 shows the state government floor area estimates, which total almost 0.2 million square feet. Unfortunately no other compilations exist for the institutional and governmental data centers associated with other organizations within California, and the effort needed to collect these data was beyond the scope of this study. For purposes of this study, we estimate a range of 0.5 Msf to 1 Msf for all institutional and governmental data centers, including state government facilities, but these estimates cry out for further research and verification.

Educational facilities

To assess the floor area in educational facilities, a sample was taken of four public and private universities of varying sizes. We contacted staff at Stanford University, the University of California at Berkeley, the University of San Diego, and San Francisco State. We assumed that high schools and other secondary educational institutions would

not typically house data centers. The active data center space totals were then combined with total figures for full time student enrollment to arrive at an average data center floor area per student of approximately 0.5 square feet per student. This figure was then used to estimate total floor area based on the total California University and College Student population of approximately 1 Million. Table 6 depicts this calculation, which results in an estimate of about 0.5 million square feet of data center floor area in the education sector.

Summary of data center floor area in California

With hosting facilities at 2 Msf, corporate facilities between 2 and 4 Msf, institutional data centers between 0.5 and 1 Msf, and educational data centers at 0.5 Msf, our estimates yield a range for total data center net floor area in California of between 5 and 7.5 Msf.

ESTIMATING COMPUTER ROOM POWER DENSITIES

Multi-tenant hosting facilities

To estimate total computer room power density for these facilities, we reviewed billing data for five hosting type data center facilities throughout the country (Mitchell-Jackson 2001, Mitchell-Jackson et al. 2002). Electricity billing data were used to find average demand in the month with the highest consumption (this month was usually the most recent one). The highest average power demand for the facility was then divided by the computer room floor area. This estimate of total computer room power density is an overestimate because it assumes that all of the power for the entire facility is used for the computer room; thus our estimate is an upper limit for the total computer room power density. Even these overestimates, however, indicate that the total computer room power density was always less than 430 W/m^2 (40 W/ft^2).[2] For comparison, typical office buildings have peak electrical demands of 54 to 86 W/m^2 (5 to 8 W/ft^2).

Total computer room power density is partly a function of the occupancy level of the space and of the racks within the space. The average rack in the Bay area data center that we studied most closely was only one-third full (the average for 14 case studies covering various types of data centers was 60% full). Unfortunately, we don't have similar occupancy data for the other data centers analyzed in the Mitchell-Jackson et al. studies, but our experiences in visiting other data centers and in talking with people who design such facilities leads us to conclude that the occupancy level for that Bay area data center of about one-third full was probably typical for hosting-type facilities.

The six hosting facilities benchmarked in the main part of this report span a range of power densities that is closer to that shown in the Uptime institute's data set on power densities for corporate facilities than to the facilities described earlier in this section of

[2] The four values were: 8 W/ft^2, 34 W/ft^2, 35 W/ft^2, and 38 W/ft^2.

this appendix. It is not known which data are most representative for all U.S. hosting facilities

Corporate data centers

For corporate data centers we summarize new data that we obtained recently from the Uptime Institute in Santa Fe, New Mexico <http://www.upsite.com/ >. To the best of our knowledge, these (along with the four corporate data centers examined in the main part of this report) are the first available and reliable measured data on power used by corporate data centers.

The data are from quarterly surveys for facilities that were members of the Site Uptime Network, for the years 1999, 2000, and 2001. In 2001, the year with the largest sample size, the number of facilities in the sample is 48, representing about 1.9 million sq. feet of net (electrically active) floor space in total. While this sample is not necessarily a statistically representative one, it does include data centers of many different types with a wide range of computer room power densities.

Figure 1 summarizes the results for all three years. Note that these computer room power densities do not include electricity used for cooling and auxiliary equipment, an omission for which we correct below. Mean computer power densities are between 22 and 25 W/ft2 over this three-year period, with the maximum being about 80 W/ ft^2 and the minimum less than 10 W/ft^2. It is not possible to discern time trends with these data given the small number of data points and the short time period.

Ken Brill of the Uptime institute estimates that total loads in data centers are typically 1.6 to 2.5 times the computer room UPS loads and our case studies confirm similar ranges of performance. For simplicity, we adopt a multiplier of 2, which yields the result that total computer room power density for these facilities ranges from 44 to 50 W/ ft^2. This total is slightly higher than that for hosting facilities, which we expect because corporate facility managers often have more control over the planning and operation of their facilities than do those managing hosting facilities.

Institutional and government and educational data centers

With the exception of the four institutional/government data centers described in the case study reports, we were unable to locate publicly available and representative data on power use for the broader population of institutional, government, and educational data centers, although this situation will change as the benchmarking activities in California and other states begins to bear fruit (Tschudi et al. 2003). The four institutional/government data centers in the main part of this report span a range that is comparable to that shown in the Uptime data for corporate facilities, thought we do not know if these four facilities are representative.

Summary of power density estimates

For purposes of the calculations in this appendix, we adopt an estimate of total computer room power density of 540 W/m^2 (50 W/ft^2) for hosting, corporate, institutional, and

educational data centers (based on the detailed data for corporate facilities). It is not known with precision how the power densities of corporate facilities compares to those of hosting, institutional, governmental, and educational data centers, though the range from the benchmarked hosting and institutional facilities reported in the case study reports is comparable to the ranges in the Uptime institute data set for corporate data center power densities.

ESTIMATING TOTAL DATA CENTER LOADS IN CALIFORNIA

A range of 5 to 7.5 Msf of floor area and an average total computer room power density of 50 W/sf yields estimated total loads for data center facilities in California in 2003 of between 250 and 375 MW. Assuming a load factor of 0.9, these loads imply electricity consumption of between 2 and 3 TWh/year.

One of the questions of concern to California policy makers is how the data center loads are distributed by utility. We address this question with the rough calculation shown in Table 7. This table distributes the electricity use estimated in the previous paragraph to major California utilities based on each utility's share of non-residential electricity use in 2001. Unfortunately, data limitations prevented us from tallying actual data center loads by utility, and true bottom-up electricity use data may differ substantially from those shown here. This initial rough calculation is the best that anyone can do until Tier 1 research completes their data collection and analysis in the coming two years (see below).

RECOMMENDATIONS FOR FUTURE WORK

The case studies for NY and California, combined with planned additional benchmarking activities, may yield insights that will help us better understand these loads. Power densities in the buildings under study may allow us to refine the power densities used above. Similarly, contacts in the industry developed from these case studies may also lead us to better estimates of raised floor area in California and the U.S. as a whole, which is an even more pressing need.

We have been frustrated in our efforts to collect credible data on floor area of corporate and institutional data centers. These facilities are often quite small and difficult to track—details on their characteristics are also often treated as trade secrets. We tried many different industry sources, including the main supplier of raised floor in the US, to no avail. There are many opinions in the industry, but none of these sources had any hard data. We also attempted two scoping calculations using business type, server shipments, rack occupancy, rack placement density, and equipment lifetimes, but these calculations were not sufficiently constrained to yield useful results. There were many possible combinations of plausible assumptions, and they led to a wide range of estimates that didn't help us much.

Currently there is no single research source that is tracking comprehensive data center floor space and capacity. Estimates of total capacity, even on a regional basis are rough extrapolations based upon small samples and industry experience. However, Tier 1

Research, a Minneapolis based market research firm recognized as the best source in data center statistics and tracking, along with AFCOM, the leading data center managers association, has recently begun an effort to resolve this issue. According to Tier 1 Research President Andrew Schroepfer, their approach is to build a comprehensive database of facilities nationwide including enterprise facilities. They expect to complete this work within the next 12 to 18 months (i.e. by the end of calendar year 2004). Tier 1 Research currently tracks multi-tenant hosting space and keeps estimates of capacity that it regularly updates via a list of 883 hosting facilities worldwide.

CONCLUSIONS

It is surprisingly difficult to obtain market data on the floor area associated with data centers (particularly corporate and institutional facilities). We continue to explore methods for estimating this number. We believe that the power density estimates are more reliable than those for floor area, because they are based on actual data from about 2 Msf of raised floor area from across the country.

Our initial estimate is that total data center loads in California are between 250 and 375 MW. The uncertainty in these estimates is very large, It is also important to note that the concern over data center loads was largely focused on the hosting facilities, which were predominantly (though not exclusively) new loads, while most of the corporate, institutional, and educational data centers have existed for decades. Only 40% of the lower power use estimate and a quarter of the higher power use estimate are associated with hosting facilities in California, and the rest are associated with corporate, institutional, government, and educational data centers. There is also great uncertainty in the future floor areas and loads, as the data center industry is evolving rapidly.

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Juarez, Richard A., Michael T. Alic, Karkhaniz Chetan S., and Brett D. Johnson. 2001. *Space Dex III—Hosting Space: Not All Space Is Created Equal—Smart, Complex Space Takes Center Stage*. Boston, MA: Robertson Stephens Inc. January 29. Available from World Wide Web: (http://www.rsco.com)

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Tschudi, William, Priya Sreedharan, Tengfang Xu, David Coup, and Paul Roggensack. 2003. *Data Centers and Energy Use – Let's Look at the Data*. Proceedings of the 2003 ACEEE Summer Study on Energy Efficiency in Industry. Rye Brook, NY: American Council for an Energy Efficient Economy, in Washington, DC. July.

Table 1: Contact information for sources of data center floor area in California

Corporate/Enterprise	
Ron Spangler Product Manager Liebert 614-888-0246	Bill Perry Technical Product Manager Tate Access Floors, Inc. 410-799-4200
Andy Schroepfer President Tier1 Research andy@tier1research.com 763-694-9992	Michael Dell Lydia Leong Senior Research Analysts Gartner, Inc. 408-468-8000
Government	
Al Smith Chief Technology Officer Teale Data Center 916-464-3934	Doug Grandy Chief Energy Policy Advisor State of California 916-375-4403
Cal Zissel IT Manager San Francisco International Airport 650-821-3350	Dennis Lionberger IT Director Marin County Civic Center 415-499-6314 DLionberger@co.marin.ca.us
Education	
Barabara Morgan Director of Strategic Technology Planning, ISNT University of California barbm@uclink.berkeley.edu 510-642-5567	John Vier Data Center Manager Stanford University 650-723-4004
Kevin Barney Data Center Facilities Manager UC Berkeley 510-642-5378	Jack Tse Director of IT Operations San Francisco State University 415-338-2627
Tom Cofflin Facilities Capital Planning Manager University of San Diego 619-921-8508	

Table 2: Floor Area for Internet Data Centers (million sq. ft.)

	Date	Estimation Year (end of year)	Coverage	Gross Floor Area	Net Floor Area	Data Center Type Co-location /Managed hosting	Number of Facilities
Salomon Smith Barney	Aug. 2000	2000 mid-year	Global	15	8	70%/30%	
(Mahedy et al. 2000)		2000		36	19		
		2001		60	33	67%/33%	
		2000 mid-year	US	8	5		
		2000		18	10		
		2001		32	18		
(Mahedy et al. 2001)	Apr. 2001	2000	Global (1)	27	14		
		2001		43	22		
Robertson Stephens	May 2000	1999	Global	7			
(Juarez 2000)		2000		21			
(Juarez et al. 2001)	Jan. 2001	2000	Global	25		69% / 31%	517
		2001		44		76% /24%	810
Lehman Brothers (Blount et al. 2001)	Jan. 2001	2001	North America	43		50-60% co-location	

Sources: Mahedy et al. 2001, Mahedy et al. 2000, Juarez et al. 2001, Juarez et al. 2000, Blount et al. 2001.

(1) SSB 2001 is not as detailed as SSB 2000. It is not possible to separate domestic floor area from international.

Table 3a. California Sites for Managed Hosting

	Salomon Smith Barney (estimate for end-of year 2000)			Robertson Stephens (end-of-year 2000)		
Company	SF/Bay Area	LA/San Diego	Sacramento	SF/Bay Area	LA/San Diego	Sacramento
Applied Theory				2		
ConXion				1		
Digex				1		
Digital Island				1		
EDS						1
Exodus	5	1		7	3	
Futurelink					1	
Genuity	3	1		2	1	
IBM	1					
Intra				1		
Navisite	2			2		
Usinternetworking	1				1	
Total	12	2	0	17	6	1

Sources: Juarez et al. 2001 and Mahedy et al. 2000.

Table 3b. California Sites for Colocation Facilities

	Salomon Smith Barney (end-of year 2000)			Robertson Stephens (end-of-year 2000)		
Company	SF/Bay Area	LA/San Diego	Sacramento	SF/Bay Area	LA/San Diego	Sacramento
AboveNet				4	1	
AT&T Worldnet	1	2		2	1	
Cable&Wireless	1			1	1	
Colo.com	3	2		3	2	
Concentric	1			1	1	
Data Return Hosting	1					
Equinix				1		
First World	2	1		1	4	
Globix	2	1		1		
Hostcentric				1		
HostPro(Micron)		1			1	
iAsiaWorks				3		
Inflow		1			2	
Intel	1			2		
Level 3				3	2	
NetNation Communications					1	
PSINet		1			1	
Qwest Communications	3			3	1	
Switch & Data Facilities	1	2	1	1	3	1
TierraNet, Inc.					1	
Universal Access				2	1	
UUNet/Worldcom	1			2	1	1
Verio				5	1	
Wavve Telecom						2
Williams Communications				1	1	
Total	17	11	1	37	26	4

Sources: Juarez et al. 2001 and Mahedy et al. 2000.

Table 4. California Data Center Hosting Floor Areas (sq.ft.)

Company	Location	2000(Mid-year)		2000(Estimate)		2001(Estimate)	
		Gross	Net	Gross	Net	Gross	Net
AT&T	CA-LA			65,000	50,000	65,000	50,000
AT&T	CA-San Diego	7,475	5,750	19,500	15,000	19,500	15,000
AT&T	CA-San Francisco	7,475	5,750	19,500	15,000	19,500	15,000
Cable & Wireless	CA-LA (TBD)						
Cable & Wireless	CA-Santa Clara	85,800	66,000	85,800	66,000	85,800	66,000
Colo.com Hosting	CA-LA	34,710	17,355	34,710	17,355	34,710	17,355
Colo.com Hosting	CA-San Diego			22,068	11,034	22,068	11,034
Colo.com Hosting	CA-San Francisco	20,576	10,288	20,576	10,288	20,576	10,288
Colo.com Hosting	CA-San Ramon			18,677	9,339	18,677	9,339
Colo.com Hosting	CA-Santa Clara			25,000	12,500	25,000	12,500
Concentric-NETLINK	CA-San Jose	10,000	5,000	10,000	5,000	10,000	5,000
Data Return Hosting	CA-San Francisco	2,500	1,250	2,500	1,250	2,500	1,250
EDS Hosting	CA-Sacramento (TBD)						
Exodus	CA-LA	123,000	61,500	123,000	61,500	123,000	61,500
Exodus	CA-Santa Clara	25,000	12,500	25,000	12,500	25,000	12,500
Exodus	CA-Santa Clara	52,000	26,000	52,000	26,000	52,000	26,000
Exodus	CA-Santa Clara	150,000	75,000	150,000	75,000	150,000	75,000
Exodus	CA-Santa Clara	125,000	62,500	125,000	62,500	125,000	62,500
Exodus	CA-Santa Clara			150,000	75,000	150,000	75,000
FirstWorld	CA-San Diego	20,000	13,340	20,000	13,340	20,000	13,340
FirstWorld	CA-San Francisco			40,000	26,680	40,000	26,680
FirstWorld	CA-Santa Clara	19,000	12,673	19,000	12,673	19,000	12,673
Genuity	CA-LA	10,900	5,450	10,900	5,450	10,900	5,450
Genuity	CA-Mountain View	146,000	73,000	146,000	73,000	146,000	73,000
Genuity	CA-Palo Alto	10,900	5,450	10,900	5,450	10,900	5,450
Genuity	CA-San Jose	10,900	5,450	10,900	5,450	10,900	5,450

Source: Mahedy et al. 2000.

Table 4 (continued). California Data Center Hosting Floor Areas (sq.ft.)

Company	Location	2000 (Mid-year)		2000 (End-of-year)		2001 (End-of-year)	
		Gross	Net	Gross	Net	Gross	Net
Globix Hosting	CA-LA			100,000	50,000	100,000	50,000
Globix Hosting	CA-Santa Clara	62,000	23,000	62,000	23,000	62,000	23,000
Globix Hosting	CA-Santa Clara			100,000	50,000	100,000	50,000
HostPro	CA-LA	13,500	10,000	20,250	15,000	20,250	15,000
IBM	CA-LA					25,000	16,250
IBM	CA-San Jose			25,000	16,250	25,000	16,250
IBM	CA-San Jose					25,000	16,250
IBM	CA-Sunnyvale					25,000	16,250
Inflow	CA-San Diego	16,800	12,000	16,800	12,000	16,800	12,000
Intel	CA-Santa Clara	85,000	43,000	85,000	43,000	85,000	43,000
Navisite	CA-San Jose	33,000	22,000	37,950	25,300	43,643	29,095
Navisite	CA-Scotts Valley	6,000	4,000	6,000	4,000	6,000	4,000
PSINet	CA-LA	5,000	25,000	5,000	25,000	5,000	25,000
PSINet	CA-San Francisco (TBD)						
Qwest	CA-LA					100,000	65,000
Qwest	CA-San Francisco	50,000	25,000	50,000	25,000	50,000	25,000
Qwest	CA-San Jose			100,000	65,000	100,000	65,000
Qwest	CA-San Jose					100,000	65,000
Qwest	CA-Sunnyvale	50,000	25,000	60,000	30,000	72,000	36,000
Qwest	CA-Sunnyvale					100,000	65,000
Switch and Data	CA-LA	35,800	17,900	35,800	17,900	35,800	17,900
Switch and Data	CA-Oakland (TBD)						
Switch and Data	CA-Sacramento			27,200	13,600	27,200	13,600
Switch and Data	CA-San Diego	28,000	14,000	28,000	14,000	28,000	14,000
Switch and Data	CA-San Francisco (TBD)						
Switch and Data	CA-San Jose			40,000	20,000	40,000	20,000
USInternetworking	CA-Milpitas	17,000	15,000	18,700	16,500	20,570	18,150
UUNet	CA-San Jose	20,000	10,000	20,000	10,000	20,000	10,000
	CA Total	1,283,336	710,156	2,043,731	1,142,859	2,438,294	1,398,054

Source: Mahedy et al. 2000.

Table 5. Floor area of state government data centers, by major agencies

	Floor area Total Sq. Ft.
Teale Data Center	43,100
Health and Human Services	45,000
Hawkins Data Center (Law Enforcement)	45,000
Franchise Tax Board	15,000
CALPERS	10,000
Legislature	10,000
California Highway Patrol	1,000
Department of Motor Vehicles	1,000
Employemnt Development Department	1,000
Secretary of State	1,000
Dept. of Corrections	1,000
Department of Veterans Affairs	1,000
Public Utilities Commission	
Air Resources Board	
Health Services	
Social Services	
Industrial Relations	
Department of Forestry	
Department of General Services	7,000
Dept. of Consumer Affairs	
Dept. of Mental Health	
State Treasurer	
State Controller	
California Youth Authority	
Board of Equalization	
Total California State Government Space:	**181,100**

(1) Source: Al Smith: Teale data center CTO for the State of California.

Table 6: Back of the envelope estimate of educational data center floor area

	Data Center Space (sf)	**Full Time Students**	**Avg sf per student**
Stanford	18,000	18,500	0.97
UC Berkeley	13,000	33,000	0.39
University of San Diego	3,500	6,000	0.58
San Francisco State	4,500	27,000	0.17
Total/Average	39,000	84,500	**0.46**
Extrapolated Total for all California Full Time University/College Students	473,878	1,026,736	**0.46**

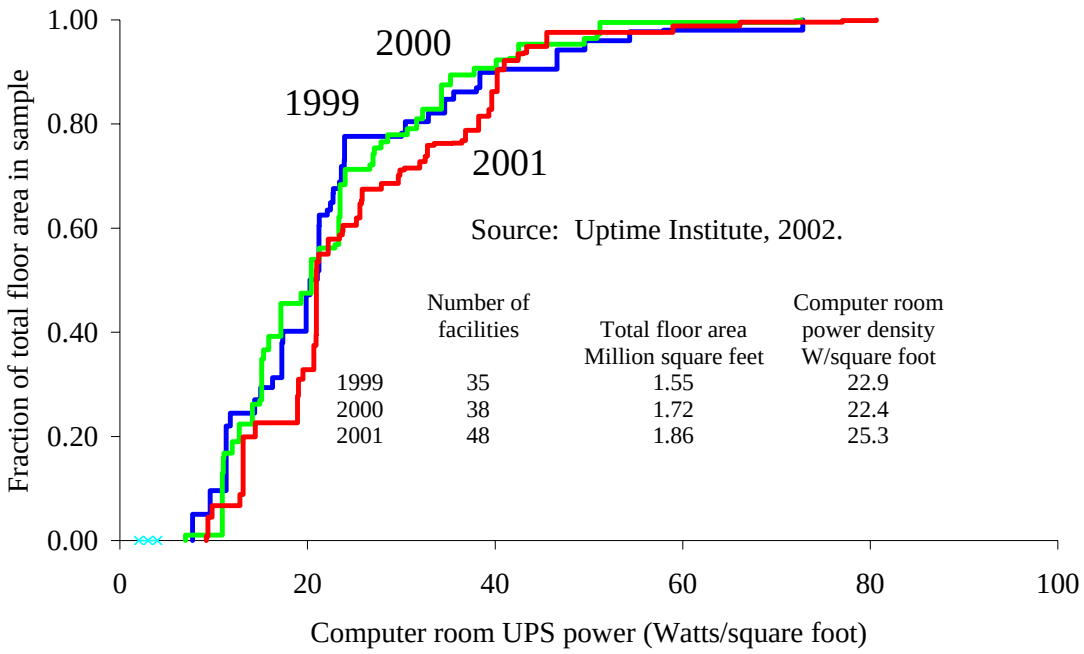
Sources : California Department of Finance: California State University, University of California, California Postsecondary Education Commission: Community Colleges, Independent Colleges & Universities, Private 2-year Colleges, Other Public Institutions.

Table 7: Rough distribution of California data center electricity use by utility

Utility	2001 California non-residential electricity use by utility % of total	Low estimate of data center electricity use GWh	High estimate of data center electricity use GWh
PG&E	35%	700	1000
SCE	36%	700	1100
SDG&E	6%	100	200
LADWP	10%	200	300
Other	14%	300	400
Total	100%	2000	3000

(1) Source of non-residential electricity use fractions in 2001:
http://www.energy.ca.gov/electricity/utility_sales.html
Downloaded 18 June 2003 by Jonathan Koomey
(2) Total data center electricity use spread across utilities in proportion to the non-residential electricity use associated with each utility.
(3) "Other" utilities include SMUD and all other municipal and private utilities in California.

Figure 1: Cumulative distribution of computer power densities (UPS power)



Source: Uptime Institute, 2002.