
# PACIFIC GAS AND ELECTRIC COMPANY
# SMALL DATA CENTER MARKET STUDY

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**Pacific Gas and Electric Company (PG&E)**
**245 Market Street**
**San Francisco, CA 94105**

The Cadmus Group, Inc.
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# Executive Summary

Historically, achieving cost-effective, energy-efficiency savings in small data centers (SDCs) has posed difficulties for utility programs. This is because the market, although very populous, is disaggregated, hard-to-reach, and the savings per efficiency project are traditionally quite small. Pacific Gas and Electric Company's (PG&E) tasked Cadmus to provide insight into the energy-efficiency opportunity in SDCs in its service territory, particularly focusing on small and medium business (SMB) customers.[1] In 2013, Cadmus conducted research for PG&E to gain additional information about specific segments of the untapped SDC market, including:

- Localized data centers (rooms with less than 1,000 square feet of white space)
- Server rooms (less than 500 square feet)
- Server closets (less than 200 square feet)[2]

For this study, Cadmus conducted the following tasks:

- 34 in-depth informational interviews with SDC managers of SMB customers
- 18 in-depth informational interviews with information technology (IT) vendors (equipment manufacturers, value-added resellers [VARs], IT service providers, and system integrators)
- Surveys with over 320 SMB customers to establish which types of SMBs had SDCs

## Major Findings

The major findings of this study covered the SDC market, decision-making for SDCs, attitudes towards energy efficiency, implemented energy-efficiency measures, and the future of SDCs.

- *About Half of SMBs have SDCs:* Cadmus learned that roughly half of the SMBs in PG&E's service territory had SDCs.[3] SMBs with the North American Industry Classification System (NAICS) codes for government, schools, healthcare, offices, and manufacturing & transportation seemed more likely to have SDCs. Also, SDC managers, typically IT staff, were very difficult to reach for in-depth interviews (over 1,000 organizations were contacted to complete 34 interviews).
- *Decision-Making is Complex:* IT vendors and SDC managers were heavily involved in decisions regarding IT equipment, but SDC managers tended to work with facility personnel for HVAC decisions.
- *Energy Efficiency is Not Top-of-Mind:* Most of the information obtained indicated that energy efficiency was not a priority at the SDCs. Eleven out of 18 IT vendors stated that SDC managers "never" or "rarely" asked about energy efficiency. IT vendors and SDC managers were unable to

[1] The definition of small and medium businesses (SMBs) are commercial customers in PG&E's service territory with a power load (at the businesses corporate level) that is fewer than 200 kW for at least nine billing periods over the past 12 months.

[2] Bailey, Michelle et al. *IDC Special Study. Data Center of the Future*. April 2006, IDC #06C4799.

[3] It is important to note that SMBs with one server only are included under the SDC category.

estimate the IT load of SDCs, and listed their top priorities as cost, uptime, and security. In one slightly favorable result, 60% of SDC managers said that they sometimes considered energy efficiency in their decision-making process. IT vendors and SDC managers ranked resource constraints as the top barrier to energy efficiency.

- *Implemented Efficiency Measures tend to be IT Equipment-Focused, rather than HVAC-Focused:* SDC managers and IT vendors indicated that the IT efficiency measures most often implemented include:
  - Energy efficient servers or uninterruptible power supplies (UPS)
  - Decommissioning unused servers
  - Data storage management
  - Server virtualization.

  When asked about the best efficiency opportunity in SDCs, SDC managers and IT vendors placed virtualization, data storage management, and migration to the cloud as the top three. Sixteen of 29 SDC managers (55%) reported using virtualization, although IT vendors estimated that 69% of their SDC customers use it. Where virtualization was implemented, roughly half of the servers were virtual servers.

- *Cloud or Co-Location? The Question about the Future of On-Site SDCs:* Given the cloud and co-location options, SDC managers and IT vendors speculate that on-site SDCs will be necessary for the foreseeable future due to concerns about security, bandwidth, and control. It was unclear which option, the cloud or co-location, was a more likely destination for these on-site SDC services.

To implement a program focused on SDCs, Cadmus recommends:

- Focusing a SDC program on IT measures and including prescriptive rebates that are perhaps linked to ENERGY STAR® specifications for servers, UPS, and data storage. This approach differs from utility programs' historical focus on larger data centers, which includes HVAC measures and customized incentives based on documented savings. It is more likely that a SDC program will achieve the small savings per site through simple prescriptive rebates for IT products.
- Paying attention to two particular measures—server virtualization and cloud migration. Although IT managers implement server virtualization less frequently in SDCs than in larger data centers, more than half of the SMB customers in this study said they are implementing it in their SDCs. As a result, a server virtualization program should target customer groups less likely to complete virtualization on their own. Industry experts are beginning to document energy-efficiency benefits of cloud migration, which program designers should explore.
- Targeting a SDC program to IT vendors (similar to the HVAC contractor model). Given the difficulty of reaching SDC managers and the recommended use of prescriptive rebates, the SDC

program should target IT vendors or use an upstream approach to target original equipment manufacturers (OEMs) and retailers (similar to the business and consumer electronics model).

- Considering the following when implementing a pilot effort:
  - Testing different outreach techniques to reach SDC managers
  - Confirming specific efficiency measures
  - Examining alternative program designs
  - Quantifying energy savings through metering.

## Project Background

Over the past decade, data center energy use in the United States has almost quadrupled.[4] Despite recent efficiency gains, data centers consume a significant and growing amount of energy—*using 2% of the electricity in the United States*.[5] Industry analysts expect data center energy consumption to continue to grow at a rate of more than 9% per year through 2020 (from a base of 200 trillion end-use British thermal units (BTUs) in 2008 to 600 trillion end-use BTUs in 2020).[6] With this increase in consumption, there are tremendous opportunities to save energy at data centers. The U.S. Department of Energy estimates reductions in energy use as high as 80% between inefficient and efficient data centers.[7]

PG&E has successfully implemented energy-efficiency programs targeted toward customers that operate data centers. PG&E's data center efficiency program portfolio provides both prescriptive and calculated incentives for the installation of energy-efficiency measures in retrofit and new construction markets. PG&E's data center program has frequent participation from larger data centers, but only minimal participation from SDCs—which are plentiful, but hard to reach with few savings per site. However, SDCs are an untapped efficiency market, representing 50% of all servers in the United States.[8]

Recent studies highlight the untapped potential of this market. The Natural Resources Defense Council and the Department of Energy believe that program implementers can increase energy-efficiency opportunities for SDCs through education, evaluation tools, and on-site efficiency evaluations.[9,10] These tools and services could support a portfolio of incentive programs that encourage energy-efficiency upgrades. Also, program design should include strategies that minimize administrative cost.[11]

PG&E tasked Cadmus to complete research about aspects of the energy-efficiency opportunity in SDCs in PG&E's territory. In order to obtain first-hand information from customers about the smaller end of the data center market, PG&E and Cadmus determined that it would be most impactful (from a project

4 Koomey, Jonathan G., Ph.D. Estimating Total Power Consumption by Servers in the U.S. and the World. Lawrence Berkeley National Laboratory and Stanford University. 2007.

5 Koomey, Jonathan G., Ph. D. "Growth in Data Center Electricity Use in 2005 to 2010." August 1, 2011. Available online: www.analyticspress.com/datacenters.html.

6 Choi Granade, Hannah, J. Creyts, A. Derkach, P. Farese, S. Nyquist, and K. Ostrowski. Unlocking Energy Efficiency in the U.S. Economy. McKinsey Global Energy and Materials. July 2009.

7 U.S. Department of Energy. "Energy 101: Energy Efficient Data Centers." May 31, 2011. Available online: www.youtube.com/watch?v=xGSdf2uLtlo.

8 Bailey, Michelle et al. "IDC Special Study. Data Center of the Future". April 2006. IDC #06C4799.

9 Bennett, Drew and Delforge, Pierre. Small Server Rooms, Big Energy Savings. Natural Resourced Defense Council. February 2012.

10 Tschudi, Bill. The Other Half of the Problem–Server Closets and Small Server Rooms. Lawrence Berkeley National Laboratory. October 2012. Presented: Silicon Valley Leadership Group Data Center Summit.

11 Bramfitt, Mark and Pierre Delforge. Utility Energy Efficiency Program Design: Server Room Assessments and Retrofits. Natural Resources Defense Council. April 2012. Available online: docs.nrdc.org/energy/files/ene_12041101a.pdf.

scope and budgetary standpoint) to approach SMB customers. Cadmus contacted IT vendors that worked with data centers of all sizes, but targeted findings about IT vendors' work with SDCs. Consequently, the results of this study provide insight about the prevalence of SDCs within the SMB population, SDC characteristics from the perspective of SMB customers, and also some general characteristics of SDCs within target markets beyond SMBs.

In 2013, Cadmus conducted research for PG&E to help it gain information about specific segments of the untapped SDC market, including:

- Localized data centers (less than 1,000 square feet)
- Server rooms (less than 500 square feet)
- Server closets (less than 200 square feet) [12]

To understand the SDC market's scale and energy-efficiency opportunities, Cadmus conducted:

- In-depth informational interviews with:
  - SDC managers of SMB customers (none of which had participated in the existing PG&E data center energy-efficiency program)
  - IT vendors such as equipment manufacturers, value-added resellers (VARs), IT service providers, and system integrators.
- Surveys with SMB customers to establish which types of SMBs had SDCs.

During this project, Cadmus asked study participants questions about SDC characteristics of, and typical equipment, decision-making, and energy efficiency opportunities in localized data centers, server rooms, and server closets in PG&E's service territory. A complete list of the question categories can be found in Appendix B.

[12] Bailey, Michelle et al. *IDC Special Study. Data Center of the Future*. April 2006. IDC #06C4799.

## Approach Summary

The approach for identifying energy savings opportunities in localized data centers, server rooms, and server closets is described below.

### *Project Initiation Meeting, Work Plan Discussion, and Project Management*

During the kickoff meeting in January 2013, project staff from Cadmus and PG&E discussed the project scope, methodology, data requirements, work plan and timetable. Throughout this project, staff from Cadmus and PG&E communicated weekly to discuss project status and next steps.

### *In-Depth Informational Interview with IT Vendor*

Cadmus called more than 100 IT vendors to complete 18 interviews to further quantify and characterize each SDC market segment. The interviews took about 30 minutes and participants had the option to receive a $50 incentive payment or donate it to the charity of their choice. Cadmus, along with PG&E, designed a survey that examined the SDC market's energy-efficiency opportunities, decision-making within SDCs, attitudes towards energy efficiency, and future direction of the SDC market. We analyzed the results of these interviews and presented these findings to PG&E during in-person meetings in April.

### *Survey of SMB Customer*

After calling over 1,000 PG&E SMB customers, Cadmus obtained information from over 300 SMB customers about on-site SDCs. From this data, we increased our understanding of the number of SDCs in PG&E's territory and, in particular, which industries were more likely to have an SDC. If the SMB customer had an on-site SDC, we attempted to reach their SDC manager for an in-depth informational interview. None of the SMB customers we contacted had participated in the PG&E data center program in the past.

### *In-Depth Informational Interview with SMB SDC Manager*

In order to have a statistically significant sample, Cadmus proposed to interview 50 SMB SDC managers to achieve 80% confidence and ±10% precision (80/10), using a two-tailed test. Similar to the IT vendor interviews, the SDC manager interviews examined energy-efficiency opportunities, decision-making within SDCs, attitudes towards energy efficiency, and future direction of the SDC. However, ultimately, only 34 SMB SDC managers were interviewed because it was more complicated and time-consuming to reach this market than originally anticipated.[13] **Therefore, given the limited number of interviews conducted with SDC managers, the information gathered from these interviews is not statistically significant, but certainly informative for guiding future efforts directed at the SDC market.**

[13] For recommendations about how to improve uptake and completion rates for interviews with SDC managers, please see Appendix E.

# Findings

This section describes Cadmus' findings from the following research efforts:

- In-depth informational interviews with IT vendors
- Surveys with SMB customers
- In-depth informational interviews with SMB SDC manager

Our research efforts explored energy-efficiency measures implemented, the motivations and barriers for participation in energy-efficiency efforts, and market conditions. More specifically, we addressed:

- SDC size, location, and function
- SDC decision-making
- SDC managers' attitudes toward energy efficiency
- Energy-efficiency barriers and opportunities
- Virtualization
- SDC migration to cloud and co-location
- IT loads

## *Phase I: Findings from IT Vendor In-Depth Interviews*

As previously discussed, Cadmus conducted interviews with 18 different IT vendors to gain insight into each SDC market segment. These interviews uncovered the valuable perspectives of IT vendors who work with multiple customers in these data center segments.

### IT Vendor Characteristics

Cadmus interviewed several different market actors with operations in PG&E's service territory including equipment manufacturers,[14] VARs,[15] IT service providers, and system integrators. The 18 vendors we contacted ranged in size from one employee to 350 employees and service different DC market size segments. Of the vendors we interviewed:

- 4 work with enterprise class DCs (greater than 5,000 square feet)
- 12 work with mid-tier DCs (between 1001 to 5000 square feet)
- 15 work with localized DCs (501 to 1000 square feet)
- 16 work with server rooms (200 to 500 square feet)
- 13 work with server closets (less than 200 square feet)

[14] Often sell directly to customers.

[15] Sell IT equipment and services, often providing integrated solutions to customers (including project planning, equipment specification, and software integration).

Figure 1 shows the types of vendors Cadmus interviewed.

**Figure 1. Role of Interviewed IT Vendors (multiple selections possible; n=18)**

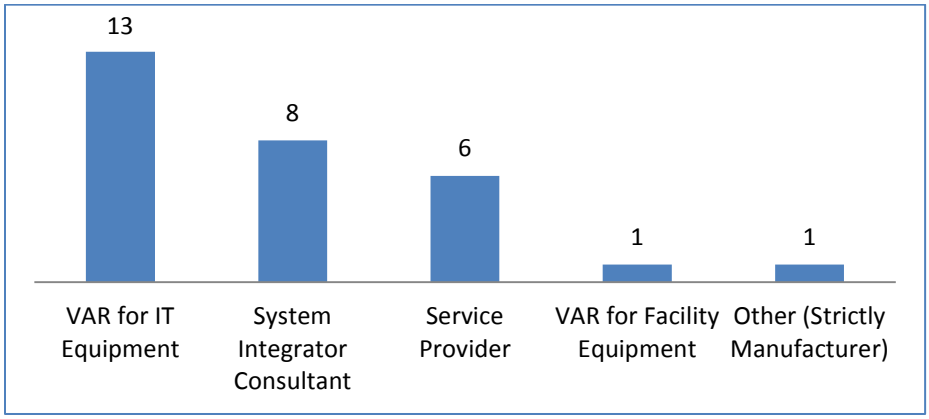



Figure 2 shows the breakdown of the IT vendors by number of employees.

**Figure 2. Number of Employees of Interviewed IT Vendors (n=17)**

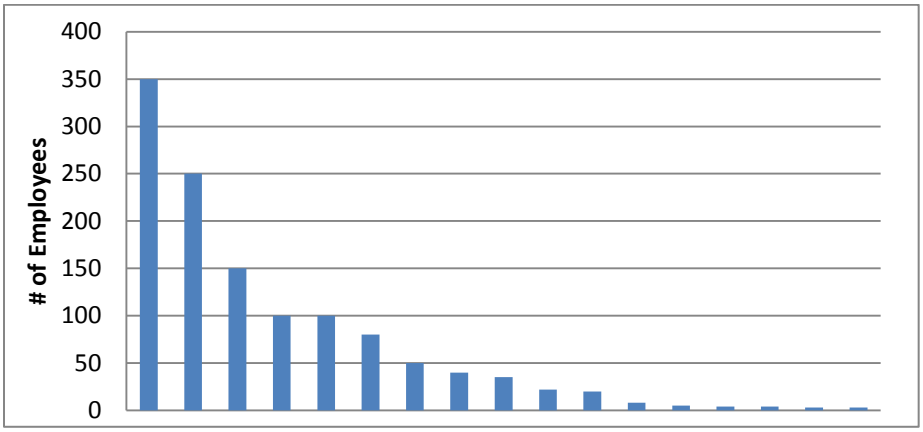
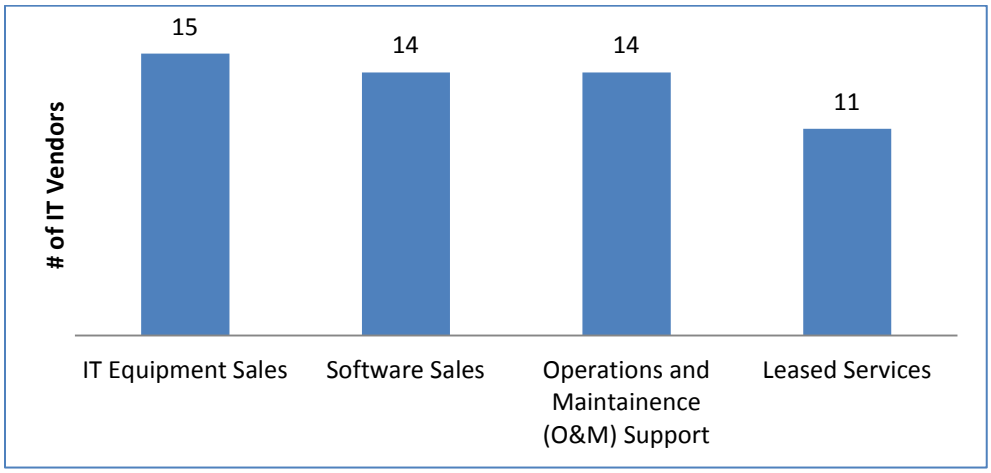



Figure 3 shows the services provided by the IT vendors.

**Figure 3. IT Services Offered by Interviewed IT Vendors (multiple selections possible; n=17)**




## Market Characteristics

Vendors provided services to customers within different end-use segments and in different NAICS codes. Cadmus found that the market for IT services is horizontal, rather than vertical, meaning that any organization, regardless of market segment, will operate a data center. Even though almost all organizations have SDCs, vendors tend to concentrate their efforts in the following segments:

- Financial services
- Professional services
- Healthcare
- Manufacturing
- Schools
- Government
- High Tech and Biotech

We asked vendors why the SDC market still existed since there are many more cost-effective and efficient opportunities like the cloud or a co-location facility. IT managers responded that SDCs are kept on-site for the following reasons:

- Inertia
- Security requirements (e.g., Sarbanes-Oxley, HIPPA)
- Reliability (not dependent solely on connectivity)
- Better speed/performance

The interviewed vendors also mentioned that there is a difference between large data centers and SDCs. Larger data centers are more flexible and open to a greater variety of products because they are not as price-sensitive. They tend to place greater emphasis on power, cooling, redundancy, and monitoring. SDCs often have no ability to control their HVAC settings, especially in server closets or rooms where they tend to rely on the building's existing HVAC system. Finally, due to the expanded flexibility and

additional access to capital, IT managers at larger data centers tend to be more concerned about the energy efficiency of their facility.

Finally, we asked the IT vendors specifically about SDCs in satellite offices and if a different energy-efficiency opportunity existed in those spaces.[16] The IT vendors that worked with satellite offices indicated that, in general, these offices operated independently from their larger corporate headquarters, and they could not differentiate the energy-efficiency opportunity in these spaces.

### Decision-Making

Interviews with the vendors indicated that they were very influential when customers conduct research and purchase IT equipment. Based on these interviews, Cadmus summarized the following decision-making process:

- Vendors provide information, recommendations, and quotes to customers.
- An internal IT manager, IT director, or vice president (VP) is often involved in the decision-making and final approval of the products and system to install.
- A VP, chief financial officer (CFO), or a CEO/president/owner gives final budget approval.

The quote that follows was taken directly from a vendor's description of the decision-making process, "In small data centers, the final proposal often goes to a CFO who has to weigh technical requests from IT with respect to available budget. Usually, [a] customer has to scale [the] proposal back. We help them scale out an acceptable design by saying what they can get and still stay within their budget."

Cadmus also asked vendors about their involvement in HVAC decisions. Many indicated that the facility manager makes HVAC decisions, rather than someone on the IT side of the business. Typically, HVAC decisions require the same approval process as IT equipment and systems. The HVAC budget most frequently came from the budget dedicated to facility-related expenses.

### Importance of Energy Efficiency

Cadmus asked how often the vendors' SDC customers asked about energy efficiency when discussing improvements to their SDCs. As shown in Figure 4, 35% "never" ask about energy efficiency and 29% "rarely" ask about energy efficiency. Only 6% "always" ask about energy efficiency.

[16] The theory behind differences between SDCs in satellite offices and stand-alone SMBs is that satellite offices, which are part of large organizations that tend to have additional resources and corporate social responsibility policies, have more refined IT policies that lead to certain energy-efficiency practices that would "tricking down" to the satellite locations causing them to be more likely to have implemented efficiency measures.

Figure 4. How Often Do IT Vendors' SDC Customers Ask About Energy Efficiency? (n=17)

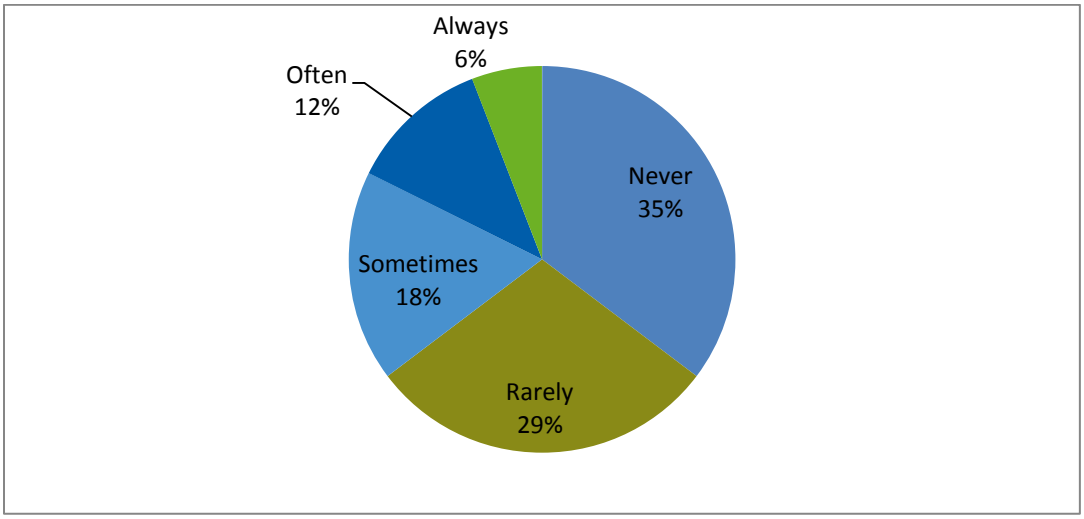
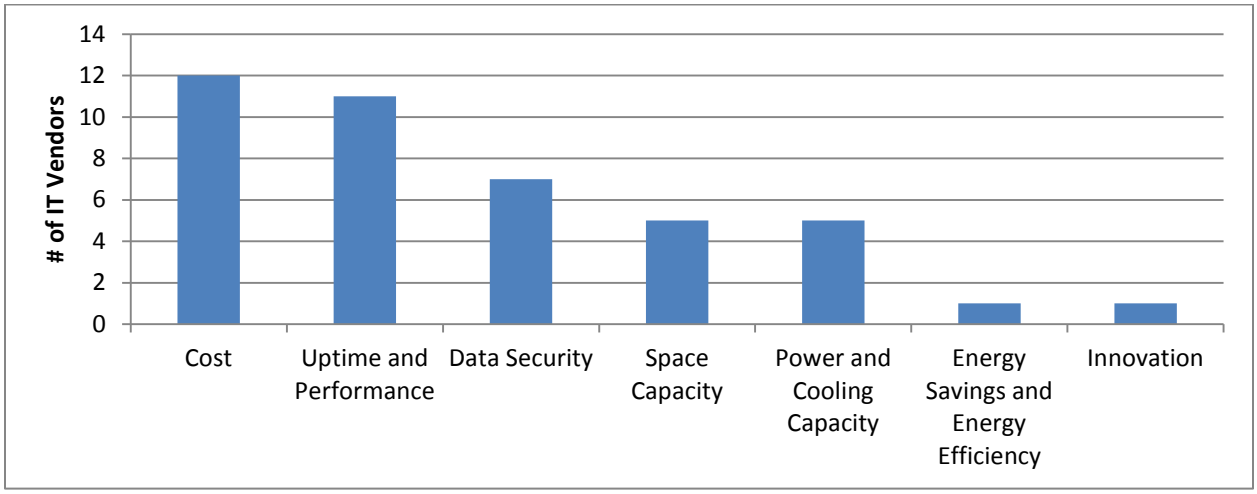



Figure 5 shows the top priorities for customers making upgrades to their data centers, according to IT vendors. Vendors most frequently reported cost, uptime, and performance as a priority (as with most data centers), followed closely by data security. Energy efficiency and innovation tied as the least popular answer.

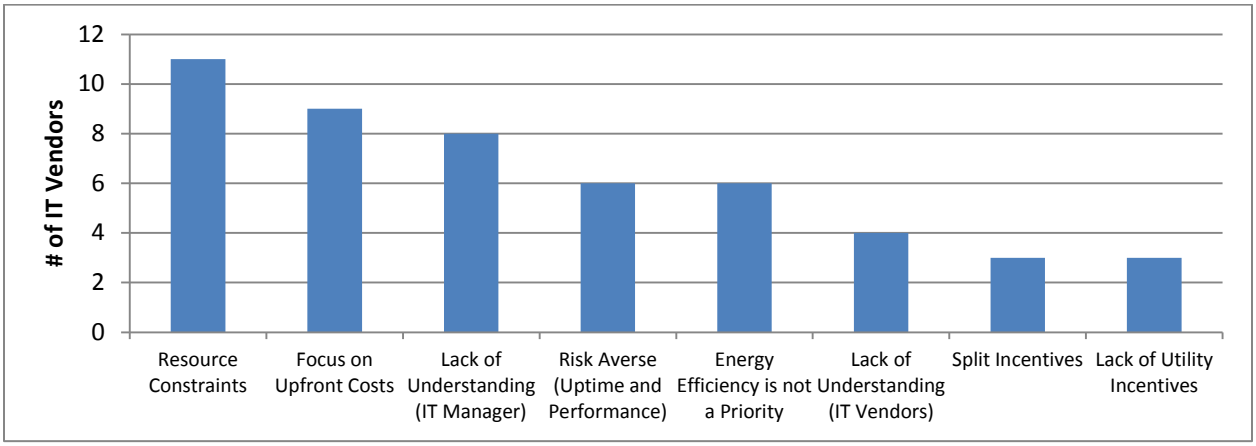
Figure 5. Top Priorities for IT Vendors' SDC Customers (multiple selections possible; n=18)




## Barriers to Energy-Efficiency Measures

As shown in Figure 6, according to IT vendors, the top three barriers to energy efficiency for SDC customers include, respectively; resource constraints, focus on upfront costs, and lack of understanding of energy-efficiency opportunities on the part of the in-house IT manager. Six out of 17 IT vendors thought risk aversion and the lack of energy efficiency were the main barriers.

Figure 6. Main Barriers to Energy Efficiency for IT Vendors' SDC Customers (multiple selections possible; n=17)




## Implemented Energy-Efficiency Measures

As shown in Figure 7, even though energy efficiency may not be a priority for SDC customers, IT vendors indicated that they did see energy-efficient measures and practices in place at SDCs. Vendors most frequently cited virtualization as an efficiency practice, followed by energy-efficient servers and uninterruptible power supplies (UPS). Decommissioning and storage consolidation were also more popular measures.

Figure 7. Energy-Efficiency Measures Listed by Implementation Rate (organized by "always" and "fairly often"; n=17)

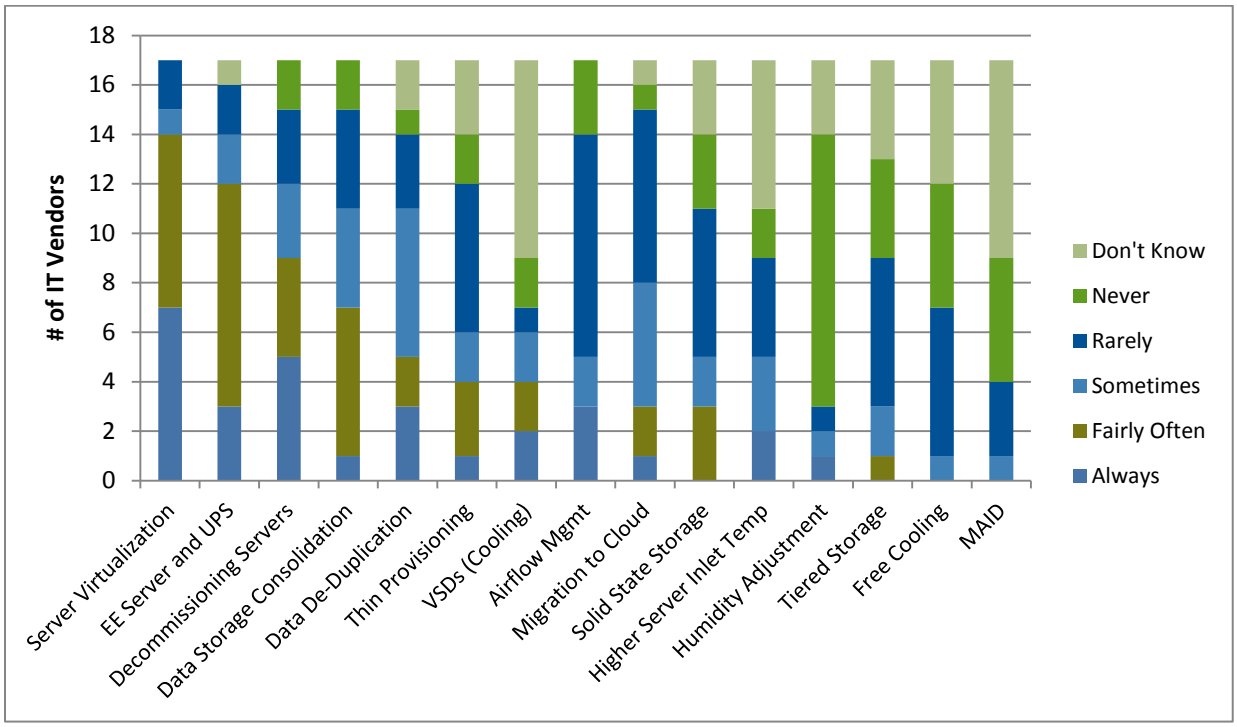
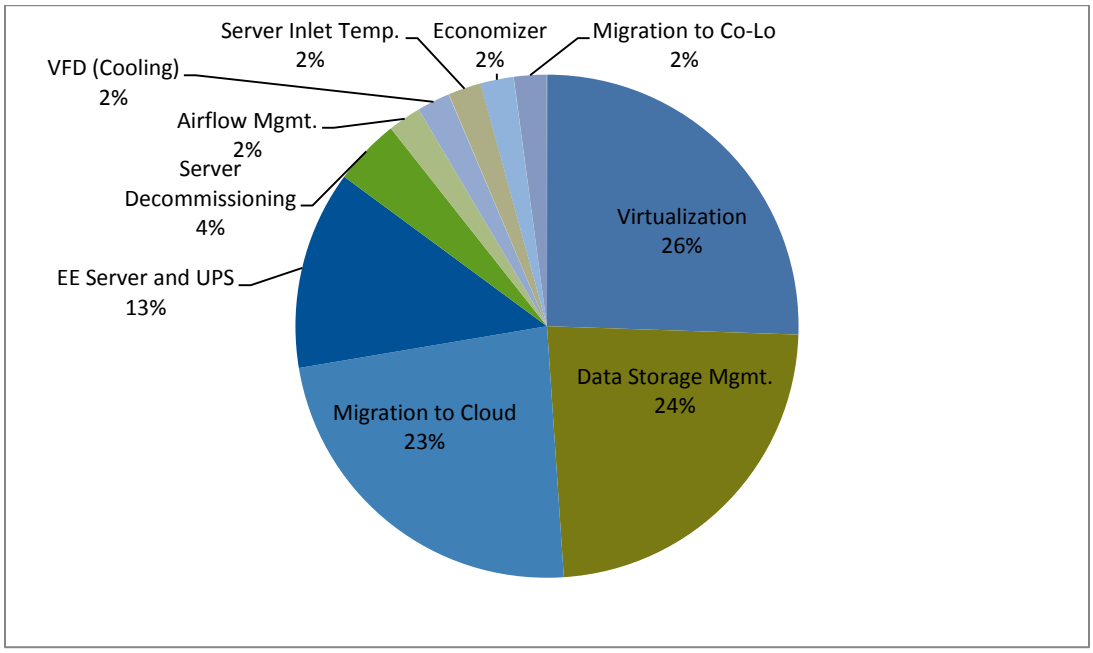


Figure 7 shows a general trend—the lack of HVAC and airflow measures in the top six energy-efficiency measures implemented in SDCs (according to IT vendors). SDCs are often smaller in size (therefore, requiring less cooling capacity) and SDC managers have limited ability to control HVAC. HVAC technologies like airflow management, variable frequency drives (VFDs), temperature and humidity adjustments,[17] and free cooling are more common in larger data centers. Please see Appendix A for a description of these measures.

### Energy-Efficiency Opportunity

Cadmus asked IT vendors which three energy efficiency opportunities had the highest potential for implementation in SDCs. As shown in Figure 8, 26% of the vendors selected virtualization, 24% selected data storage management, and 23% selected migration to the cloud. Some vendors acknowledged that, although server virtualization is the one measure they see most often implemented, it still represents the best energy-efficiency opportunity given how many organizations have implemented it and how many others are currently considering implementing it as a part of the next server upgrade.

**Figure 8. Top Three Energy-Efficiency Opportunities (n=17)**




### Virtualization

In the past, data center operators would run a single application on each server. With this "one workload, one box" approach, servers tend to run at a low "utilization rate", which means a fraction of the total computing resources are engaged in useful work. With server virtualization, administrators can run multiple applications on one physical host server, thereby consolidating server resources. In other words, multiple servers can work virtually simultaneously on one physical host server. Therefore, instead of operating many servers at low utilization, virtualization combines the processing power onto

[17] Humidity control was likely infrequently implemented because of northern California's dry climate.

fewer servers that operate at higher total utilization and save energy. More importantly, virtualization improves scalability, reduces downtime, enables faster deployments, and expedites disaster recovery.[18]

Due to these benefits, virtualization has become commonplace in large data centers. In 2011, a survey of 500 large enterprise data centers found that 92% of the data centers used virtualization to some degree. [19] However, virtualization is less common in SDCs; an informal survey of 30 small businesses found that only 37% used virtualization.[20]

As described previously, IT vendors felt that server virtualization was both the most implemented measure in SDCs and the measure with the most remaining opportunity. On average, 69% of IT vendors' SDC customers have implemented server virtualization. However, of those that do virtualize, 53% of servers used by each customer were virtual machines. In other words, although many had virtualized, there were still many servers remaining to virtualize (31% of SDCs, and roughly half of those servers in the 69% of SDCs that had already completed some level of virtualization).

In addition, the IT vendors indicated the following about server virtualization:

- Organizations have implemented virtualization projects with as few as two servers.
- Customers were virtualizing on their own (without assistance from utility programs or without much encouragement from vendors). This signals a high potential for freeridership.
- The average refresh rate of servers to be four years.
- There is no particular market or organization type that favors virtualization more than another market or organization type.
- The main barriers to virtualization in SDCs were:
  - Costs, given how inexpensive low-end volume servers have become.
  - Complexity, as one vendor stated, "[Customers] don't have the manpower to take on a project like that. It is only a one to two person shop. [They] can't do research while managing other equipment."
  - Risk aversion, as one vendor stated, "Small businesses are going to be risk averse. They are going to try to get more out of older servers."

[18] *The Economics of Virtualization: Moving Toward an Application-Based Cost Model*, IDC, 2009. Available online: www.vmware.com/files/pdf/Virtualization-application-based-cost-model-WP-EN.pdf

[19] "Veeam Launches V-Index to Measure Virtualization Penetration Rate". VEEAM. 2011. Available online: www.veeam.com/news/veeam-launches-v-index-to-measure-virtualization-penetration-rate.html

[20] Bennett, Drew and Delforge, Pierre. *Small Server Rooms, Big Energy Savings*. Natural Resourced Defense Council. February 2012. Available online: www.nrdc.org/energy/files/Saving-Energy-Server-Rooms-IssuePaper.pdf

### Migration to Cloud or Co-Location Services

Cadmus asked IT vendors about the future of on-site SDCs, given the growing use of cloud services and the availability of co-location facilities. IT vendors provided the following feedback:

- SDCs will eventually head to a co-location facility or to the cloud, but, if not already doing so, are currently reluctant because these centralized infrastructures do not have the necessary level of information security or bandwidth to keep SDCs' businesses operating safely and smoothly.
- When asked about the timeline before almost all servers would be in the cloud, many were not able to or did not feel comfortable predicting, but those that did said about five to 10 years.
- SDCs would migrate to a co-location facility well before they would go to the cloud as certain industries (e.g., financial services, banks, and hospitals) will have trouble migrating to the cloud because of data security issues.
    - Also, those that need high bandwidth will leave their servers at local brick and mortar locations and not the cloud, unless technology improves.
- Some applications will continue to be stored locally, including high security data, phone services, and file and print servers.

IT managers, for whom migration represents an outsourcing of some of their primary job functions, may report migration decisions differently than what is reported by IT vendors. Further research about this potential bias was not within the scope of this study, but would be beneficial for a follow-up study.

### IT Load

IT Vendors did not have a good understanding of the actual IT load in an SDC. However, they provided the following estimates:

- Server closet capacity included one server rack
- Server room capacity included three (3) server racks
- Localized data center capacity included approximately 14 server racks

Based on the SDC manager interviews, the number of servers in the racks varied from one in a closet to approximately 20 per rack in some of the larger customers. In all categories, on average, SDC managers reported that the typical server has two processors and six cores.

## *Phase II: Findings from SMB Customer Survey*

Cadmus called 1,040 SMB customers which were sampled from a list provided by PG&E. During the calling process, 321 SMB respondents reported whether or not they had an SDC. Table 1 shows the results sorted by North American Industry Classification System (NAICS) codes. Of the 321 respondents, the Government sector had the highest percentage of respondents with SDCs (87%), followed by Schools (75%), Healthcare (62%), and Offices (56%). Forty-four percent of the respondents were Offices. The respondents were located primarily in San Francisco, the Central Valley, and Silicon Valley.

Table 1. Survey Results of SMBs Regarding Presence of SDC (n=321)

| NAICS Code | Respondents | Percentage of Respondents | "Yes, Have SDC" | Percentage "Yes, Have SDC" |
|---|---|---|---|---|
| Government | 15 | 5% | 13 | 87% |
| Schools | 4 | 1% | 3 | 75% |
| Healthcare | 26 | 8% | 16 | 62% |
| Offices | 140 | 44% | 78 | 56% |
| Manufacturing & Transportation | 40 | 13% | 21 | 53% |
| High Tech/Biotech | 6 | 2% | 3 | 50% |
| Agriculture | 25 | 8% | 7 | 28% |
| Retail | 50 | 16% | 10 | 20% |
| Hospitality | 11 | 3% | 1 | 9% |
| Food Processing | 2 | 1% | 0 | 0% |
| Chemicals & Minerals | 0 | 0% | 0 | n/a |
| Petroleum | 0 | 0% | 0 | n/a |
| **Total** | **321*** | | **153** | **48%** |

*Cadmus grouped two of the 321 respondents into the Residential classification and did not show them here.

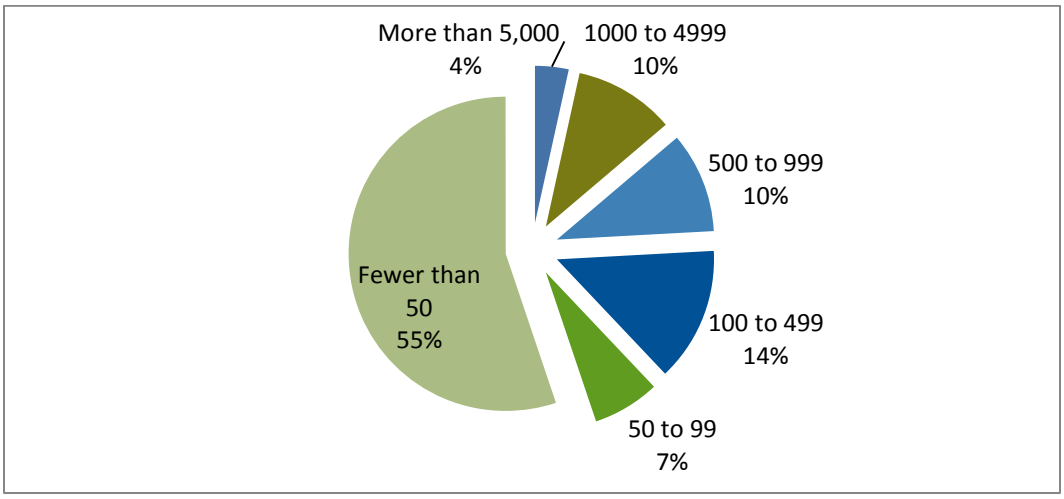
## *Phase III: Findings from SMB Customer SDC Manager In-Depth Interviews*

Thirty-four of the 321 survey respondents agreed to have their SDC manager complete a longer, in-depth interview. Interviews lasted anywhere between 10 and 30 minutes, depending on the length of time the customer was willing to dedicate. All of the information from the SDC manager contributed to the analysis in this report.

### SMB Customer Characterization

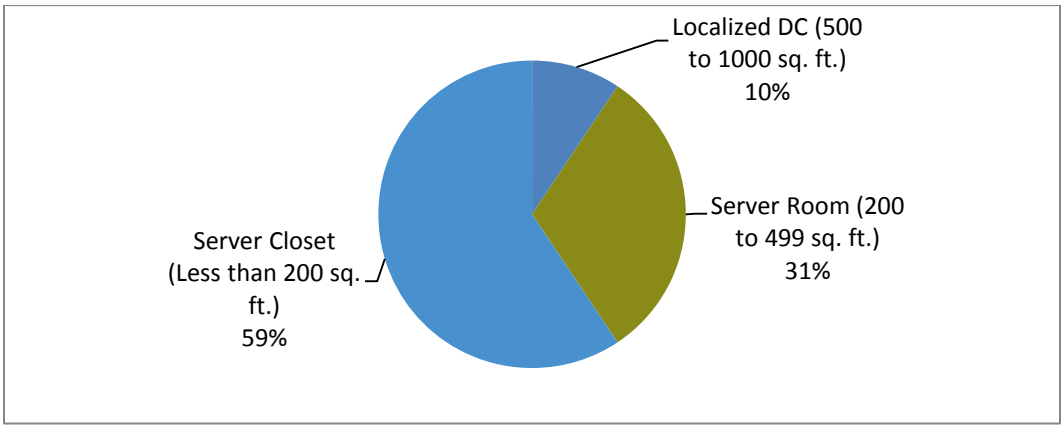
Slightly more than half of the 34 SMB customers were organizations with fewer than 50 employees, as shown in Figure 9. However, some of the SDC managers were from SMBs with more than 1,000 employees.

Figure 9. Number of Employees (n=29)



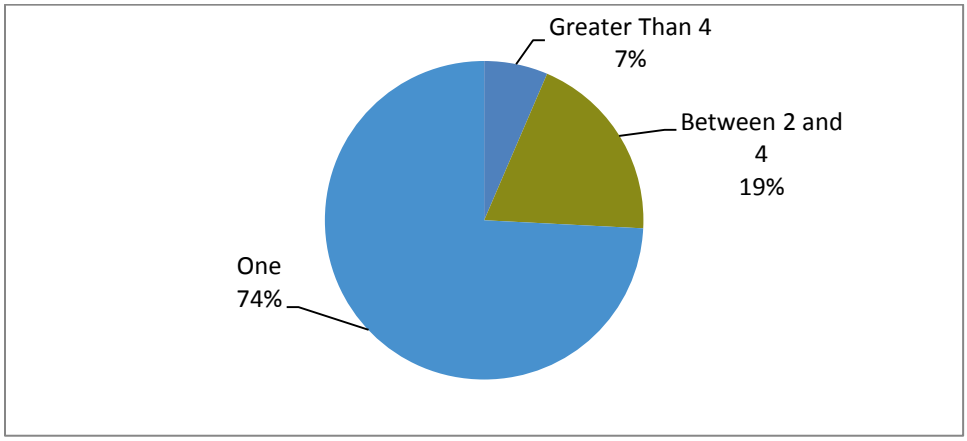

As shown in Figure 10, SDC managers that participated in this study mostly oversaw server closets (59%).

Figure 10. Average SDC Size (n=32)



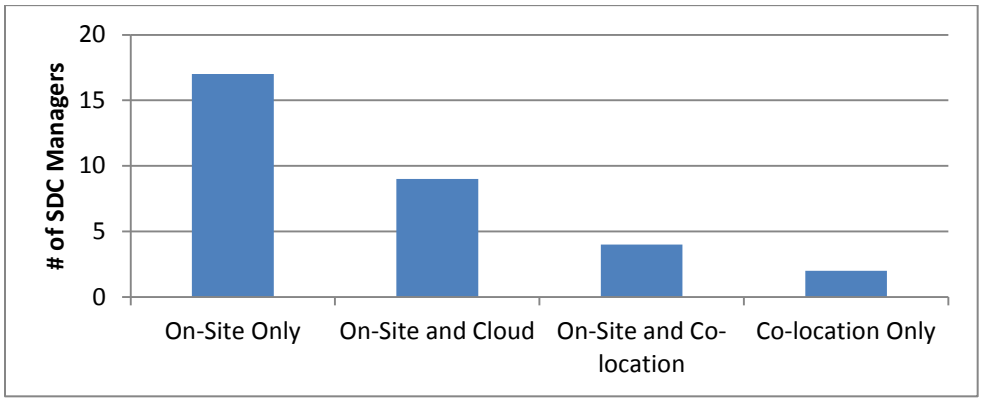
As shown in Figure 11, 26% of SMBs had multiple on-site SDCs.

**Figure 11. Number of SDCs per SMB (n=31)**




As shown in Figure 12, 17 of 32 SDC managers did not use any co-location or cloud services. Those that did use co-location or cloud only used them for certain applications. Two SDC managers had their entire SDC in a co-location facility.

**Figure 12. Use of Cloud/Co-Location Facility (n=32)**

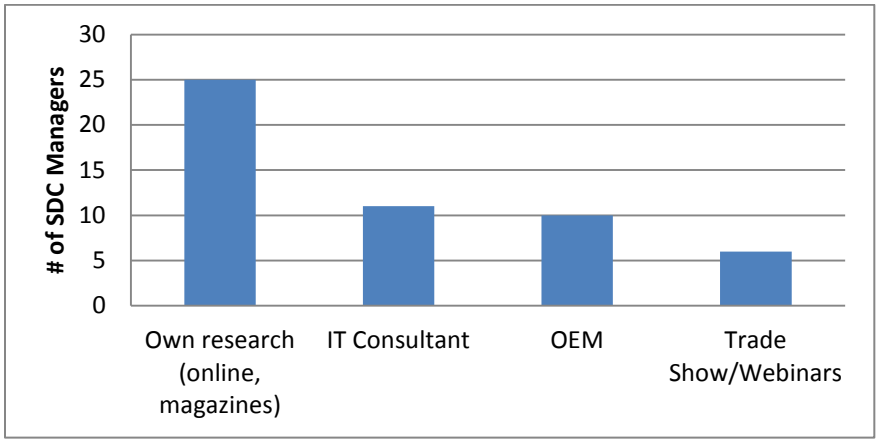



## Decision-Making

Forty-five percent of SDCs used an IT vendor (n=31). Those SDCs may have a dedicated in-house IT person, as well. Fifty-eight (58%) of SDC managers reported that they were involved in the HVAC decision-making process (n=31). This conflicts with the responses from the IT vendors, which indicated that vendors were not involved in HVAC decisions. Eight of 16 SDC managers stated that they could control temperature and humidity in their SDC. The remaining 8 used the building's general settings, which as to be expected given the high number of server closets in the sample.

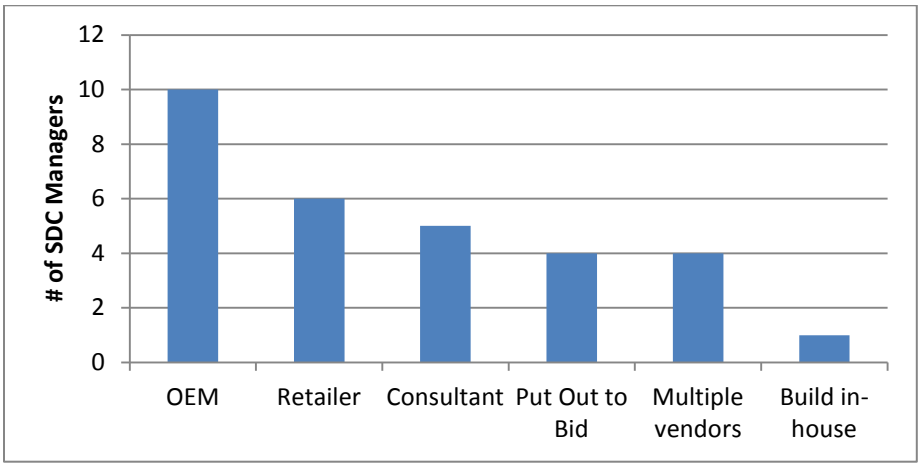
As shown in Figure 13, 25 of 34 SDC managers primarily obtained their general information on data center products and services through their own research. Eleven of 34 SDC managers used their IT consultant and 10 of 34 managers used the OEM to gather general information.

Figure 13. Source of Data Center Product and Service Information (multiple selections possible; n=30)




Cadmus also asked the SDC managers about IT equipment purchases. As shown in Figure 14, SDC managers purchase IT equipment most often from the OEM, then from a retailer, and third from an IT consultant.

Figure 14. Where SDC Managers Purchase IT Equipment (multiple selections possible; n=29)




## Importance of Energy Efficiency

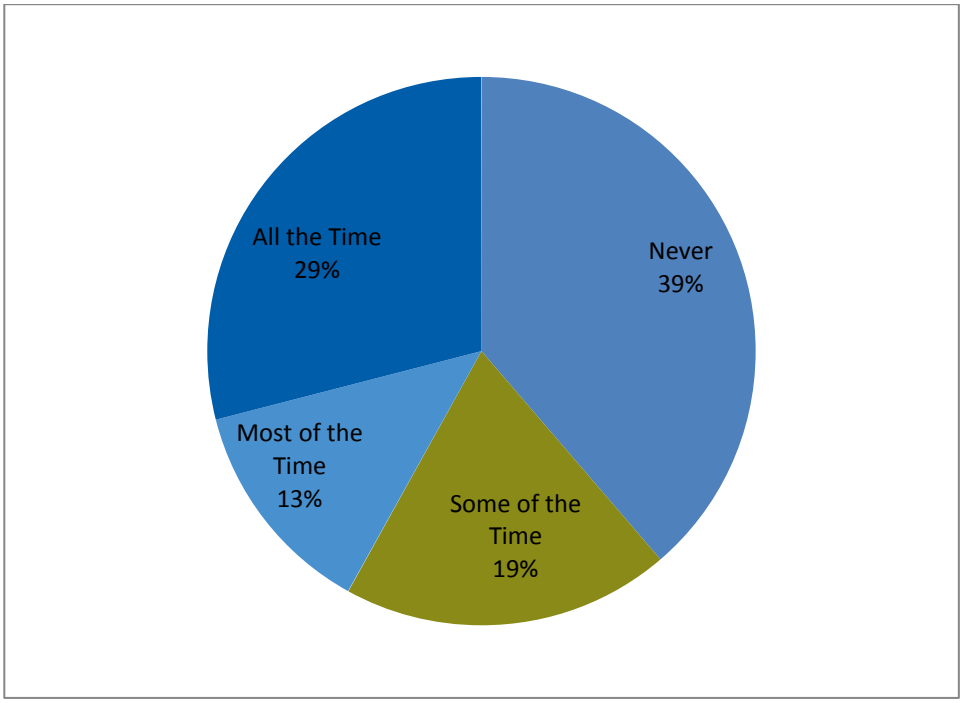
For an SDC manager, the importance of energy efficiency varies. As shown in Figure 15, more than 60% of SDC managers reported considering energy efficiency in IT purchases. However, this contrasts with the other results of the SDC manager survey, namely:

- 67% do not request information about energy efficiency
- 77% do not know their IT load

When asked directly whether they consider energy efficiency when making IT decisions, SDC managers typically responded, “Yes, whenever possible (if makes economic sense).”

These results are also different from the results of the IT vendor survey. Approximately 65% (11 out of 17) IT vendors said SDC managers "rarely" or "never" asked about energy efficiency (see Figure 4). Given these conflicting results with other SDC interview questions and the information from the IT vendor interviews, SDC manager self-report bias may have occurred.

**Figure 15. Frequency That Energy Efficiency Factors Into IT Decisions (n=31)**




As shown in Figure 16 and Figure 17, attitudes towards energy efficiency (as expected and described by the IT vendor) improved as the size of the data center increased (by number of servers and number of employees).

Figure 16. Frequency That Energy Efficiency Factors Into IT Decisions by Number of Servers (n=27)

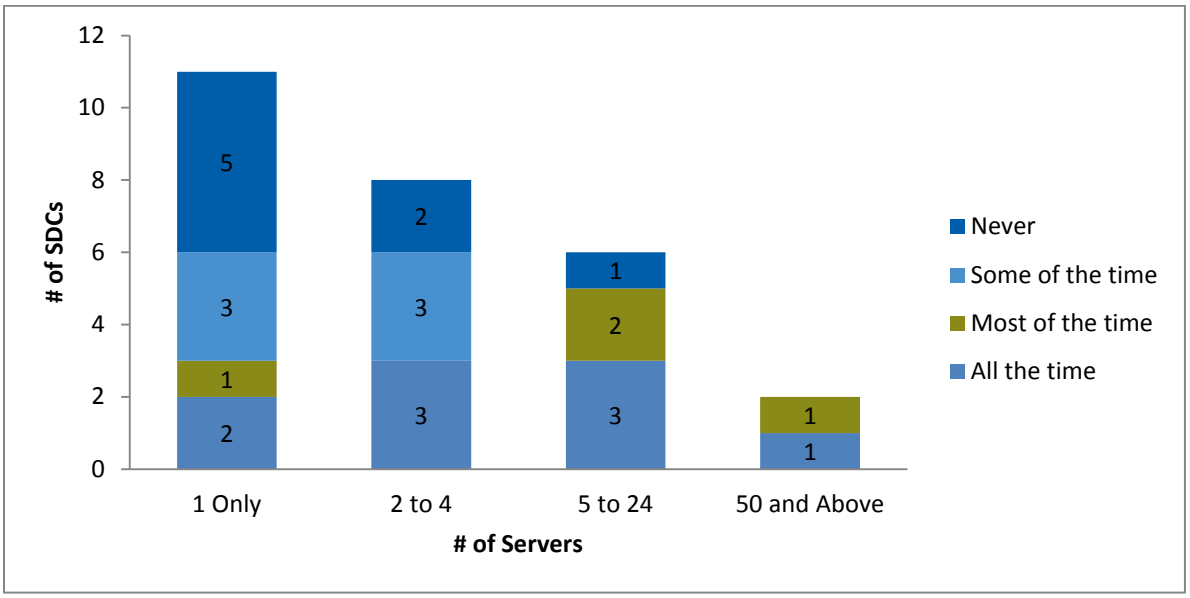



Figure 17. Frequency That Energy Efficiency Factors Into IT Decisions by Number of Employees (n=26)

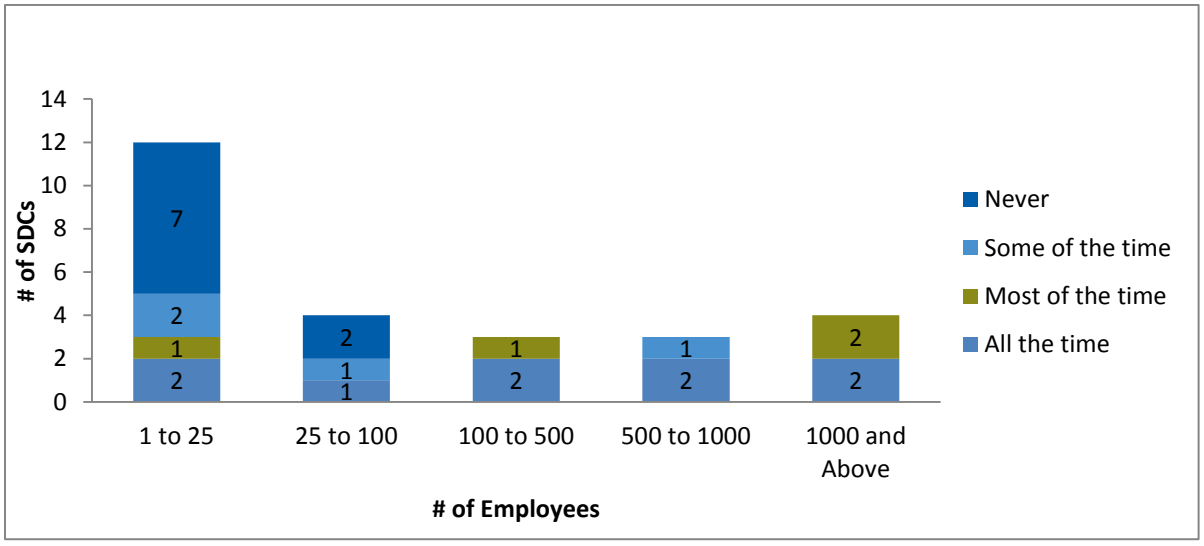
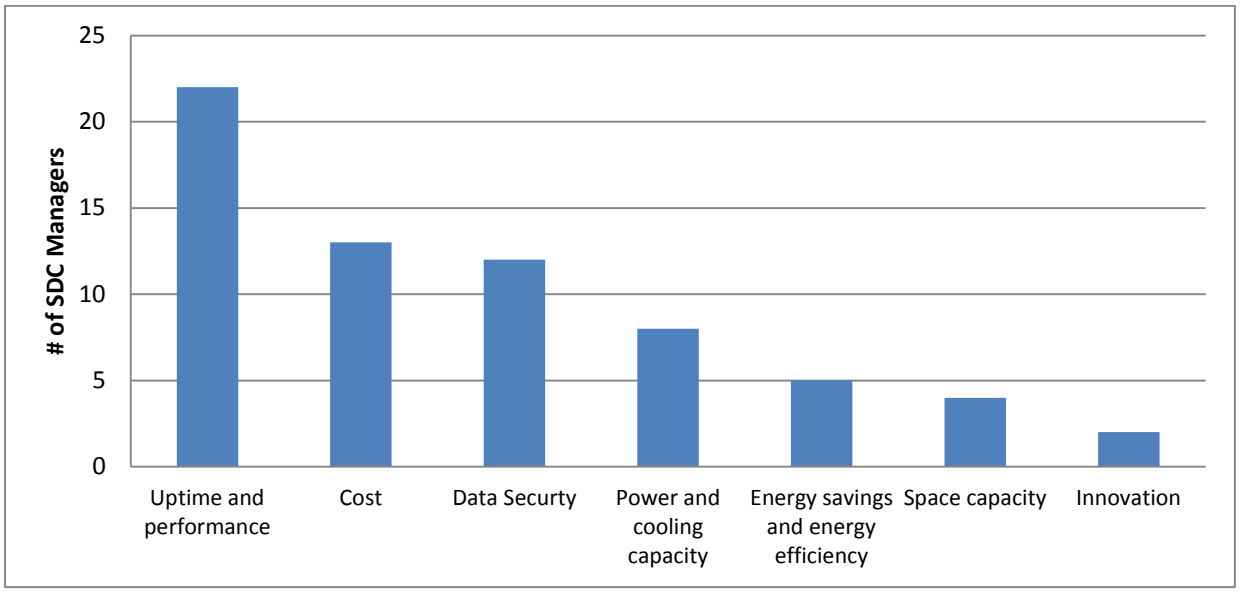



Figure 18 shows that the top priorities for SDC managers were the same as those revealed in the interviews with IT vendors (see Figure 5). The top three priorities for SDC managers included uptime and performance, cost, and data security.

Figure 18. Top Priorities for SDC Managers (multiple selections possible; n=33)




## Barriers to Energy-Efficiency Measures

As shown in Figure 19, SDC managers cited resource constraints, lack of energy efficiency as a priority, and high upfront costs as the top three energy-efficiency barriers in SDCs. These results were very similar to the results of the IT vendor interviews, except that "energy efficiency is not a priority" was not in the top three for IT Vendors.

Figure 19. Main Barriers to Energy Efficiency for SDC Manager (multiple selections possible; n=28)

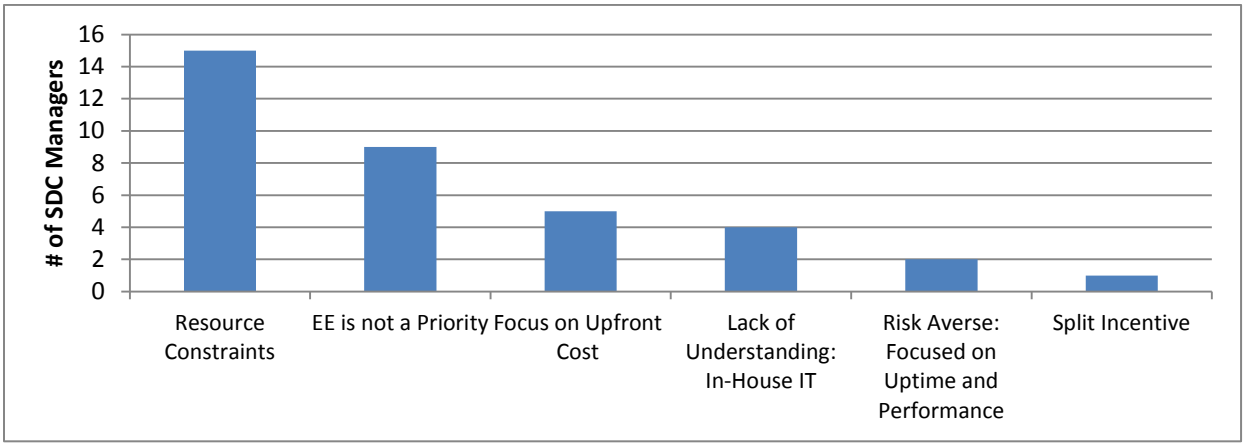


Table 2 contains a sample of quotes from SDC managers about the barriers they experience when attempting to pursue energy efficiency in their SDCs.

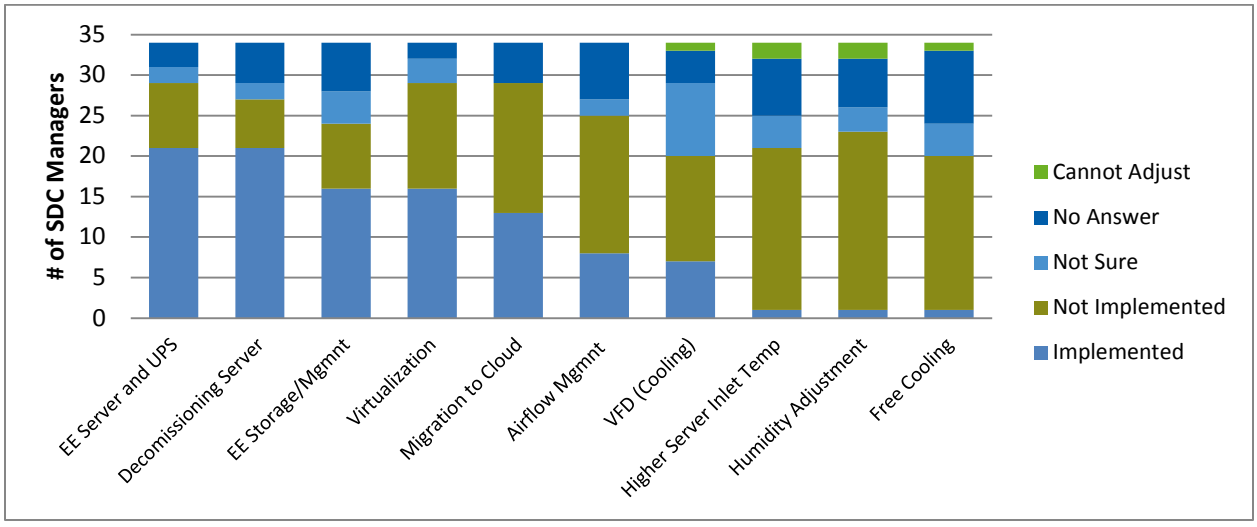
**Table 2. Barriers to Energy Efficiency: Verbatim Statements from SDC Managers**

| Finding Category | Verbatim Statements |
|---|---|
| Energy use is inconsequential | • "It is a small room and the energy use is small relative to the rest of the office."<br>• "Footprint is so small that it is negligible when choosing between different products." |
| Lack of understanding (on behalf of the IT manager) | • "I'm unfamiliar with what is available or what could happen. If PG&E provided some ideas about what to do, it would be helpful. I would be interested in a whole-building audit."<br>• "There is a lack of education at the top level. If folks were more knowledgeable about efficiency, it might factor into decision, but not sure it is a high priority." |
| Already doing what they can | • "Don't have any [barriers]. As a county, we have an energy independence program, which has fostered a culture of breaking down barriers."<br>• "Don't have much to do. We get the most energy-efficient servers that we can, but aren't constantly changing out or adding servers." |

## Implemented Energy-Efficiency Measures

As shown in Figure 20, SDC managers most often implemented the following energy-efficiency measures: energy efficiency servers and UPSs, decommissioning of unused servers, data storage management, and server virtualization. These responses were very similar to those described by IT vendors (see Figure 7) and once again emphasized IT measures rather than HVAC measures. This also reflects the fact that most of the SDCs were server closets and rooms without HVAC opportunities.

**Figure 20. Implemented Energy-Efficiency Measures (n=34)**

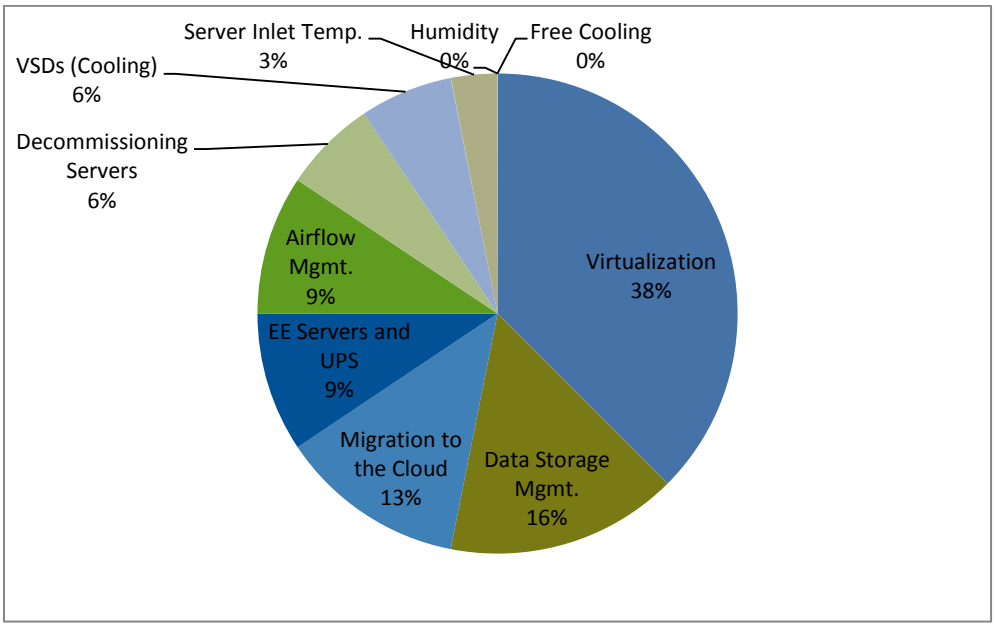



## Energy-Efficiency Opportunity

Cadmus asked SDC managers which three energy-efficiency opportunities would have the highest potential of implementation in the SDCs. As shown in Figure 21, the top three energy-efficiency opportunities, according to SDC managers, include server virtualization (38%), data storage

management (16%), and migration to the cloud (13%). These top three priorities align with the responses from the IT vendor (see Figure 8).

**Figure 21. Top Energy-Efficiency Opportunities (multiple selections possible; n=17)**




## Virtualization

As mentioned in the last section, both IT vendors and SDC managers listed virtualization as the energy-efficiency measure with the most remaining opportunity. SDC manager interviews also revealed the following about virtualization:

- As shown in Figure 19, 16 of 29 SDC managers (55%) had implemented virtualization. This is lower than the 69% of IT vendor's customers who had implemented virtualization.
- Nine of the 16 SDC managers that had implemented virtualization cited that 45% of their servers were virtual servers. (IT vendors reported an average of 53%.)
- Based on 14 responses from SDC managers, not all servers were virtual servers due to high upfront costs (six responses), unique applications they could not virtualize (five responses), security (one response), and lack of time (one response) to complete the process.
- Based on 21 responses from SDC managers, the average server refresh rate was six years (with a minimum of a refresh every two years and a maximum of every 15 years).

## Migration to Cloud or Co-Location Services

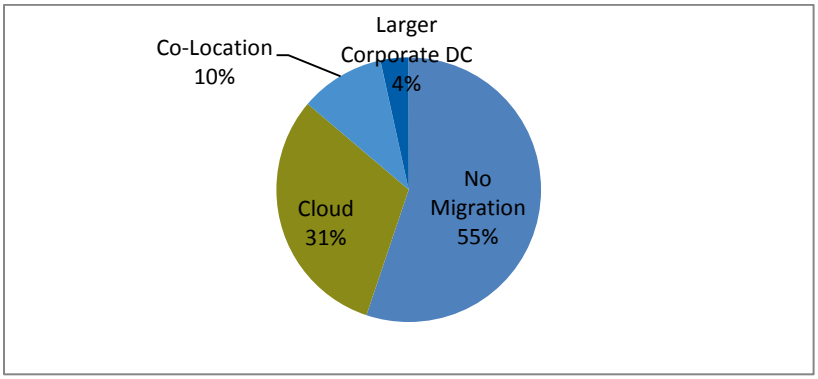
Cadmus also asked SDC managers about the future for on-site SDCs, given the availability of co-location facilities and the growing use of cloud services. SDC managers provided the following feedback:

- SDCs exist due to concerns about security, bandwidth, and control. Managers reported their organizations remain concerned about the security of their data at off-site locations; the speed

with which systems can transfer and deliver data; and the ability to control, manage, and oversee their physical servers.

- The interviewed SDC managers like to have the following server types and applications on-site: domain controller, file server, print server, e-mail server, and financial applications.
- As shown in Figure 22, when we asked where on-site SDC services may migrate, more than half of SDC managers reported "no migration", while others mentioned the cloud (31%), co-location (10%), and a larger corporate data center (4%).

**Figure 22. Destination of On-Site SDC Services (n=29)**

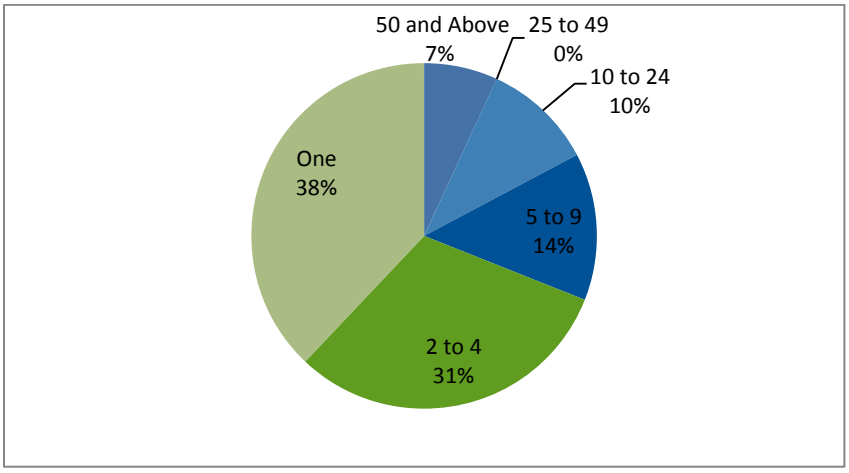



## IT Loads

Recent research found that an SDC in a typical office building consumes 23**%** of annual energy costs while an SDC in a high efficiency office building consumes 40 to 50% of annual energy costs.[21]

Similar to IT vendors, SDC managers did not know their typical IT loads, but the data indicated that SDCs tended have fewer than five servers (with a median of three servers, see Figure 23). SDC managers also reported, on average, two processors per server and six cores per processor.

**Figure 23. Number of Servers (Total) per SDC (n=29)**




[21] Monroe, Mark. E Source Energy Manager's Roundtable: "Who needs skeletons? We've got servers in the closets". 2013

# Conclusions and Recommendations

Cadmus provides the following conclusions and recommendations based on 18 in-depth interviews with IT vendors, 34 in-depth interviews with SDC managers, and a survey of over 320 SMB s in PG&E's territory.

## *Conclusions*

### Market

- **SDC managers are hard to reach.** During the process of conducting in-depth interviews with SDC managers at SMBs in the PG&E territory, Cadmus contacted 1040 organizations in order to complete 34 SDC manager interviews. The SMB list provided by PG&E only included a general phone number. Reaching the SDC manager was a challenge given the:
  - Presence of a typical company policy of not allowing unexpected phone calls through to the SDC manager.
  - SDC managers had limited available free time, which was further exacerbated by the length of the survey.
- **IT vendors are much easier to reach than SDC managers.** Cadmus only contacted approximately 100 IT vendors to complete 18 IT vendor in-depth interviews. The IT vendors were, in general, much more willing to make themselves available for the survey (e.g., scheduling times later in the week if unavailable initially) than SDC managers. IT vendors perhaps saw the value in participating in the in-depth interview (e.g., potential rebates from utilities for IT measures in SDCs) and were more willing to share their expertise and opinions than the SDC manager.
- **Fewer than 50% of SMBs have a SDC.** As learned from our survey of 321 SMBs, fewer than half of the SMB customers that responded to the SMB customer survey reported use of an SDC.
- **Certain NAICS codes exhibited higher SDC presence.** Through conversations with 321 SMBs, organizations with the following NAICS codes demonstrated a higher likelihood of having an in-house SDC: Government, Schools, Healthcare, Offices, and Manufacturing & Transportation.
- **SDCs are mainly server closets.** Fifty-nine percent of the SDCs were server closets of less than 200 square feet (according to SDC managers).
- **SMBs reached use co-location facilities and the cloud services.** Only four out of 34 on-site SDCs used a co-location facility in addition to having an on-site SDC. Two of the 34 SDCs were located in a co-location facility. Nine of 34 SMBs used cloud services in addition to the services provided by on-site SDCs.

### Decision-Making

- **SDCs use IT vendors.** Forty-five percent of SDC managers used an IT vendor.
- **IT vendors strongly influence IT decision-making.** During the decision-making process, both IT vendor and SDC manager developed recommendations or quotes about the IT facility upgrades. These recommendations required final approval from a VP or the CEO/president/owner before implementation.
- **IT vendor did not influence HVAC decisions.** Facility or property managers, in conjunction with SDC managers, typically made the HVAC decisions and did not involve the IT vendor.

### Importance of Energy Efficiency

- **Many interview results indicate a lack of awareness of energy-efficiency opportunities in SDCs.** Eleven out of 18 IT vendors say SDC customers "never" or "rarely" asked about energy efficiency. Neither SDC managers nor IT vendors had an understanding of the IT loads in SDCs. Sixty-seven percent of SDC managers do not typically request information about energy efficiency. Both IT vendors and SDC managers agreed that top data center priorities were uptime, limiting costs, and high levels of data security.
- **Limited interview results point toward a growing awareness of energy efficiency in SDCs.** Sixty percent of SDC managers say that they at least sometimes considered energy efficiency in their decision-making process.

### Barriers to Energy-Efficiency Measures

- **Resource constraints hinder energy-efficiency measures.** Both IT vendors and SDC managers cited resource constraints as the top barrier that prevented customers from investing in energy efficiency. Table 3 compares both parties' top five barriers preventing energy efficiency measure implementation.

**Table 3. Top Five Barriers to Energy Efficiency**

| Ranking | According to SDC Managers: | According to IT Vendors: |
|---|---|---|
| 1 | Resource constraints | Resource constraints |
| 2 | Energy efficiency not priority | Focus on upfront costs |
| 3 | Focus on upfront costs | Lack of understanding  of in-house IT manager |
| 4 | Lack of understanding f in-house IT manager | Risk averse |
| 5 | Risk averse | Energy efficiency not priority |

- **Importance of energy efficiency increases with size of the data center.** Data indicated that as the number of SDC servers or SMB employees went up (which is linked to a decrease in resource constraints), the importance of energy efficiency in decision-making went up.

### Implemented Energy-Efficiency Measures

- **IT measures, not HVAC measures, are most often implemented in SDCs.** SDC managers and IT vendors reported the following energy-efficiency opportunities were most often implemented: installation of energy-efficient servers or UPSs, decommissioning unused servers, data storage management, and server virtualization.
- **IT measures and the cloud represented best efficiency opportunities.** SDC managers and IT vendors both believed that the best energy-efficiency opportunities in SDCs were server virtualization, data storage management, and migration to the cloud.

### Virtualization

- **More than half of SDCs are using at least some virtualization.** Sixteen of 29 SDC managers (55%) used virtualization. IT vendors estimated that 69% of SDC customers used virtualization.
- **In SDCs using virtualization, roughly half of the servers are virtual servers.** Nine SDC managers indicated that 45% of their servers were virtual servers. IT vendor estimates were 53%.
- **Costs, complexity, and risk aversion were cited as main barriers.** IT vendors mentioned that SDCs often choose to stay with their existing, inexpensive, simple, and familiar low-end volume servers to meet lower levels of IT need.

### Migration

- **SDCs will continue to serve a purpose.** Even with co-location and cloud service options available, on-site SDCs will continue to be necessary due to concerns about security, bandwidth, and control. Given these concerns, SMBs will continue to store certain types of applications (e.g., financial, health records) and server types (e.g., files, domain controller) locally.
- **Unclear where SDCs will migrate services.** More than half of the SDCs indicated they will not migrate to the cloud or co-location. Of the SDCs indicating they would migrate, most indicated that the cloud would be the destination. However, IT vendors indicated that co-location would be a more likely destination than the cloud.

### IT Loads

- **SDCs are unaware of their IT load.** Neither SDC managers nor IT vendors could estimate their IT load, but they did provide information on the number of servers in an SDC (median = three).
- **SMB IT load estimated.** In an exercise, Cadmus estimated the total SDC IT load of SMBs to be 4-12% of the overall PG&E SMB energy use.

## *Recommendations*

### Focus on IT, not HVAC

In general, programs targeted toward SDCs should focus on IT systems, rather than HVAC systems since there did not seem to be a large opportunity for HVAC-oriented upgrades (e.g., VFDs, airflow

management, or free cooling) at these smaller facilities. Prescriptive incentives may be an option given that ENERGY STAR is releasing new specifications for UPSs, storage, and servers. The ENERGY STAR specification for storage includes requiring that storage units can accommodate advanced storage management utilities.

### Exercise Caution with Server Virtualization

Server virtualization is implemented less frequently in SDCs than in larger data centers. However, it is important to note that IT vendors reported that many of their SDC customers had implemented server virtualization on their own, which is a freeridership concern.

As such, it is important to target a server virtualization (providing education, services, and incentives) program to specific customer groups who are less likely to complete virtualization on their own. Additionally, freeridership concerns should be discussed with evaluation groups before embarking on a program to ensure all efforts are understood and documented.

### Explore Migration to Cloud or Co-Location Services

PG&E should explore migration to the cloud or to a co-location facility. Although limited by bandwidth, control, and security concerns, many understand the efficiency gains and are beginning to study and document these efforts.[22] In fact, utility programs exist where customers are incentivized for moving to the cloud or to a co-location facility.

### Target IT Vendors, OEMs, and Retailers

IT vendors play a large role in the decision-making process at SDCs. As a result, PG&E should consider an SDC-focused program with a midstream IT product incentive targeting IT vendors (similar to the HVAC contractor model). It should also consider an upstream approach targeting OEMs and retailers (i.e., similar to the business and consumer electronics model). We based these recommendations on the finding that SDC managers are a difficult to reach and do not often incorporate energy efficiency into their decisions.

### Conduct Further Research

PG&E is considering completing a pilot targeting efficiency in SDCs to provide further information about the opportunity. Before rolling out a full-scale SDC program, the pilot should:

- Explore different marketing strategies to reach SDC managers. Explore different association lists to see if SDC managers could be more directly contacted.

[22] Masanet, Eric. "The Energy Efficiency Potential of Cloud-based Software: A U.S. Case Study", Lawrence Berkeley National Laboratory, June 2013.

- Conduct a pilot with customers or IT vendors to confirm: 1) efficiency measures that could be implemented at most SDCs; 2) program designs most appropriate for the hundreds of thousands of SDCs and their small per site potential savings (e.g., prescriptive incentives); and 3) energy savings estimates for IT measures via long-term, real-time metering.
- Examine elements of the cost-benefit calculation, including: incremental costs, effective useful life of new measures, remaining useful life of pre-existing measures, IT equipment efficiency metrics that allow for savings calculations over changing loads, and the validity of burnout and early replacement savings.

Future research will be very valuable to help understand whether cost-effective market potential is available in the SDC segment. It will also help to assess which measures and opportunities might be most beneficial. Finally, future research can help program administrators understand what program designs might be most effective in this market. Also, collaboration amongst program administrators may be required in order to have an impact on the energy consumption in SDCs. As a result, it would be helpful to understand whether market potential and the associated strategies differ by program administrator territory.

# Appendix A. Glossary

**Airflow Management**: In a data center, cool air from computer room air conditioners is brought into the front of server racks and rejected out the back of the server as hot air. Air flow management is an efficiency term used to reflect the separation of hot and cold air streams and includes such measures as hot aisle/cold aisle, containment, and properly deployed air flow management devices like blanking panels, structured cabling and grommets.

**Cloud**: Cloud computing is a general term for anything that involves delivering hosted services over the Internet. Cloud services are sold on demand by the minute or hour and are fully managed by the provider (the user only needs an internet connection and a computer. There are 3 categories of cloud services. Infrastructure-as-a-Service (IaaS) is where an organization outsources the equipment used to support operations, including storage, hardware, servers and networking components (e.g., Amazon Web services). Platform-as-a-Service (PaaS) is where the consumer creates the software using tools and/or libraries from the provider and controls software deployment and configuration settings and the provider provides the networks, servers, storage, and other services. Finally, Software-as-a-Service (SaaS) is a software distribution model in which applications are hosted by a vendor or service provider and made available over the Internet (e.g., Gmail, Salesforce, MSFT Office 365).

**Co-Location Facility**: A data center facility in which a business can rent space for servers and other computing hardware. Typically, a co-location facility provides the building, cooling, power, bandwidth and physical security while the customer provides servers and storage. Space in the facility is often leased by the rack, cabinet, cage or room.

**Decommissioning Servers**: In many data centers, "comatose" servers exist that are plugged but doing not useful work. Locating and decommissioning those servers saves energy.

**De-Duplication**: Software that can condense the amount of data stored at many organizations by more than 95%, by finding and eliminating unnecessary copies.

**Energy-Efficient Servers and Uninterruptible Power Supplies (UPSs**): More efficient servers, that use better power supplies, chips and advanced power management techniques, and UPSs (e.g., multi-mode or modular), are currently available on the market. The EPA ENERGY STAR program currently certifies efficient servers and UPSs.

**Energy-Efficient Storage/Management:** The use of more efficient use of storage through better management (e.g., thin provisioning, tiering, de-duplication) or more efficient storage devices (e.g., solid state storage, MAID).

**Free Cooling**: The use of outdoor air to cool the data center and is also known as air side economization.

**High Server Inlet Temperature**: Raising temperature of the cold air entering the server inlet. ASHRAE guidance recommends an upper limit for server inlet temperature of 80.6 °F. However, many data centers keep the server inlet temperatures around 60 °F, wasting energy.

**Humidity Adjustment:** Ways to reduce energy consumption related to keeping humidity constant in the data center, including expanding the allowable range of humidity in the data centers and using adiabatic means to maintain humidity levels.

**Localized Data Center**: These facilities may serve only the local, specific needs of a call center or office operation (for example), with general, large-scale IT services provided by a data center in another location (measuring between 500 and 1,000 square feet).

**Massive Array of Idle Discs (MAID)**: MAID saves power by shutting down idle disks and powers the disks back up only when an application needs to access the data. A MAID system can have hundreds or even thousands of individual drives and often can replace tape libraries.

**Server Closet**: The smallest-scale data center (measuring less than 200 square feet).

**Server Room**: A type of data center that does not often have dedicated cooling or power delivery systems or climate conditioning equipment (measuring between 200 and 499 square feet).

**Small and Medium Business (SMB)**: Commercial customers in PG&E's service territory with a power load that is fewer than 200 kW for at least nine billing periods over the past 12 months.

**Small Data Centers (SDCs):** Server rooms, server closets, and localized data centers collectively
IT Vendors – The group of market actors that are involved with an influence data center purchasing and operation decisions. This group includes manufacturers, IT service providers, system integrators, and value-added resellers (VARs).

**Solid State Storage**: Energy-saving solid-state storage, with no spinning discs, is increasingly becoming an option because of lower prices and "read" speeds that are orders of magnitude faster than hard discs.

**Split Incentive:** A data center energy efficiency barrier that exists when the IT person (with a capital budget) is unwilling to invest in more expensive but more efficient equipment because the energy savings benefits accrue to the facilities group (with the operating budget).

**Storage Consolidation:** Also called storage convergence; a method of centralizing data storage among multiple servers to save energy. There are three storage consolidation architectures in common use: network-attached storage (NAS), redundant array of independent disks (RAID), and the storage area network (SAN).

**Thin Provisioning:** Allocating storage on a just-enough, just-in-time basis by centrally controlling capacity and allocating space only as applications require the space – thus powering only storage currently in use and saving energy.

**Tiered Storage:** Increasing efficiency by storing data according to the relative demand for that data. In other words, low-priority data rarely accessed information is stored on higher latency equipment that uses less energy.

**Variable Frequency Drives (VFDs) Cooling:** Placing VFDs on the fans of computer room air conditioning units or air handlers, thus allowing for variable speeds on fans. Fan power varies with the cube of fan speed, so reducing fan speed by one half will reduce power draw by one eighth.

**Virtualization**: Running the workload of multiple physical servers on one physical host server housing multiple "virtual" servers.

## Appendix B. Interview Question Topics

During this project, Cadmus asked study participants the following questions about localized data centers, server rooms, and server closets in PG&E's service territory.

- What is the size of SDC market?
- What is the average number of servers?
- Do certain types of businesses tend to more frequently have SDCs? Where is this market located? In what NAICS codes are SDCs most or least prevalent?
- What are the influential data center stakeholders in the decision-making process?
- How are data center decision-making responsibilities shared within a typical organization?
- Which decision-makers are the best targets for energy-efficiency outreach efforts?
- Are SDCs serving as primary data centers for the organization contacted, or do they exist to perform secondary functions that require on-site presence?
- Is migration to cloud services or larger, off-site facilities (co-location) anticipated? If so, when?
- What energy-efficiency opportunities exist?
- What free ridership concerns (if any) exist?
- What are the wants and needs of these potential customers? How do these align with current program offerings?
- What are the challenges with reaching this market in PG&E's service territory?
- What is the role of an on-site SDC given co-location and cloud service opportunities?

CADMUS

# Appendix C. IT Vendor Interview Guide

## *Overview*

This interview guide will attempt to better understand data center stakeholders' business, how they interact with their customers, and gain some insight into how customers make decisions.

PG&E's High-Tech Energy Efficiency program has successfully provided incentives for data center (DC) efficiency measures for a number of years. As a technical contractor to PG&E, The Cadmus Group is interested in obtaining information about the **small DC market** (customers that manage data centers that are less than 1,000 square feet) **and its energy efficiency opportunities.** With this information, PG&E could develop a select package of incentive programs to encourage energy efficiency upgrades in the small DC space. This interview will take about 30 minutes of your time. We understand your time is valuable and as a token of our appreciation, if you complete the interview, we are offering you a $50 Visa gift certificate or a donation in your name to a charity.

## *Stakeholder Background Information*

The first questions will help us to understand the role your company plays in the data center market in terms of data center size and organization type.

1. What role does your company have in the data center market? I'm going to read a list. Please tell me which apply. (Read all options through and select all that apply)
    a. Value-added reseller (VAR) for IT equipment (regional or local).
        i. If so, for which manufacturer?
    b. VAR for facility equipment (regional or local).
        i. If so, for which manufacturer?
    c. System integrator consultant (typically for a larger organization)
    d. Service provider who offers long term maintenance, ongoing monitoring, or help desk services.
    e. Other. Please describe.

2. How many employees does your company have?

3. What DC size(s) do you typically provide services to? Do you have a limit to the size of data center you will over services to?
    a. Enterprise class: greater than 5,000 square feet
    b. Mid-tier: 1001 to 5000 square feet
    c. Localized: 501 to 1000 square feet
    d. Server rooms: 200 to 500 square feet
    e. Server closets: less than 200 square feet

    (Insert answers: _____. These answers will become "selected relevant size(s)" for the remaining questions.)

4. (If respondent only focuses on certain market sizes) Why don't you provide services to the following markets?

***If respondent does not select C, D, or E please thank him/her for his/her time and ask if they have any contacts within that space. END***

5. What services do you provide to each DCs size (read selected relevant size(s) from Question 4)? What services/products contribute to your revenue stream? (do not read; mark all that apply)
   a. IT equipment sales
   b. Software sales
   c. Leased services
   d. Operations and maintenance support
   e. Other, not listed

6. Do you have customers that operate DCs in PG&E's territory? (If NO, take note)

7. About how many customers have you worked with over the last year within each DC size category?

8. Roughly what percentage of your work/sales comes from each DC size?

9. What DC target market type(s) do you typically provide services to? (read all options and select all that apply)
   a. **Branch or satellite DC**, which is a branch office of a large bank whose main IT services may be provided via larger corporate DCs, co-location or cloud service (e.g., remote site data center; regional data center; local data center)?
   b. **A small DC in a small to medium sized organization (SMOs)** whose main IT services may be **externally managed** via co-location or cloud service?
   c. **A small DC of SMOs** where all IT services are **internally managed** through an on-site (hosted) small DC?

   (Insert answers: _____. These answers will become "selected relevant market type(s)" for the remaining questions.)

10. What types of organizations do you provide services to?
    a. Small Office (1 to 10 workers)
    b. Food Service
    c. Grocery
    d. Large Office
    e. Financial Services
    f. Small Retail
    g. Large Retail (big box chain)
    h. Colleges/Universities
    i. State Government
    j. Local Government

k. Federal Government
l. Agriculture
m. Food Processing
n. Healthcare
    i. Hospital
    ii. Clinic
o. High Tech/Biotech
p. Hospitality
q. Schools
r. Chemicals and Minerals
s. Manufacturing and Transportation
t. Petroleum
u. Wastewater and Water Treatment
v. Other, not listed

(Insert answers: _____. These answers will become "selected relevant organization type(s)" for the remaining questions.)

11. What industry segment tends to have smaller DCs?

12. Do you focus specifically on one or more of these organization types?

13. How do you typically reach out to potential new customers? How do you develop new business leads?

The remainder of the survey will focus on your experiences with the small DC market, which are identified as server rooms, server closets, and localized DCs. For each topic we discuss, we'd like to understand whether you observe distinct differences between subsets of the small DC market. The subsets of the DC market are defined as:

- Differently-sized small DCs: localized DCs, server rooms and server closets
- Different organization types (e.g., small office, grocery).

Please keep these different market definitions in mind when answering the following questions.

### *Small DC Energy Efficiency Opportunities*

In this section, we would like to understand more about the energy efficiency opportunities available in small DCs. This next question asks about energy efficiency opportunities in small DCs. By energy efficiency opportunity, I mean an equipment retrofit or upgrade that reduces energy use.

14. First, I'm going to read a list of energy efficiency opportunities. Please tell me how often you see the energy efficiency technology or practice implemented in small DCs. Please tell me if you have: never seen this implemented, sometimes seen it implemented, seen it used fairly often, always seen it implemented, or don't know.
    a. Server virtualization/consolidation
    b. Decommissioning of unused servers
    c. Better data storage management

    a. Data storage consolidation
    b. De-duplicate data
    c. Thin provisioning
    d. Organize storage by tiers
    e. Solid state storage
  d. Purchasing energy-efficient servers and power supplies
  e. Properly deployed airflow management strategies
    a. Blanking panels, grommets, and structured cabling
    b. Hot aisle/Cold aisle setup
    c. Containment enclosures: in row cooling, strip curtains, chimney cabinets
  f. Variable speed fan drives on cooling equipment
  g. Adjusting server inlet temperatures closer to the high end of ASHRAE recommended temperature range of 80 degrees F.
    a. Humidity adjustments
    b. Turn off humidifiers
    c. Broaden humidity range
    d. Install adiabatic systems (misters, foggers, ultrasonic) - YES
  h. Free cooling
    a. Air-side economizer
    b. Water-side economizer
  i. Migration to the cloud

15. From the list that I just read, what 3 technologies have the most opportunity and potential to be implemented in small DCs? Please explain.

16. Do your small DC customers request information about the energy performance of existing or new equipment and services or how to manage their energy consumption?
    a. (If yes) Could you please provide an example of a time when this happened; describing what the customer and you did?

17. What are the main barriers to implementing energy efficiency technologies or practices? (Do not read; mark all that apply)
    a. Risk averse: focused on uptime and performance
    b. Resource (labor, monetary, technical expertise) constraints
    c. Focus on initial/upfront cost rather than long-term payback
    d. Energy efficiency is not a priority
    e. Lack of standards and best practices
    f. Who pays the bill and who gets credit for cost-saving? Split incentives and complex decision-making involving facilities, IT, and external vendors
    g. Lack of understanding on the part of IT vendors
    h. Lack of understanding on the part of the in-house IT manager
    i. Lack of utility incentives that decrease upfront cost
    j. Other (please specify)

18. If you think about data centers that are less than 1,000 and compare them with data centers that are larger than 1,000 square feet, do you believe that efficiency opportunities, attitudes towards energy efficiency and barriers differ?
    a. Depending on the data center size?
    b. Depending on the data center market type?
    c. Depending on the organization type?

19. Is there a difference between how a branch or satellite DC received upgrades/retrofits when compared with an SMO with externally or internally managed services?

### *Server Virtualization Opportunity*

PG&E is particularly interested server virtualization and how the remaining opportunity varies across different types of small DCs that you work with.

20. Does the adoption of virtualization differ by;
    a. Small DC Market Type?
    b. Small DC Size?
    c. Organization Types?

21. What percentage of customers with small DCs currently virtualized?

22. Of those small DCs that use virtualization, what percentage of their servers is virtual?

23. What is the typical server refresh rate in years?
    a. Do server replacements tend to be replacement on burnout or early replacement?

24. How much does virtualization typically save or cost the customer (when comparing the cost of purchasing new virtual hosts and licenses to the cost of purchasing additional non-virtual servers to cover additional capacity)?

25. Why are small DCs not using virtualization?
    a. Why not 100% adoption?
    b. What are perceived barriers to virtualization?

### *Determining Typical IT Loads of Small DC*

The next few questions are about energy consumption. For the next two questions, please tell me if the answers vary with DC size. That is, are the answers different for localized data centers, server rooms, and server closets?

26. What is the typical overall IT load (in kW, read at the UPS) of each DC size class?

27. Can you estimate how many:
    a. Server racks, servers per rack, and KW per server are generally observed in DCs of each size?

b. Processors per server and number of cores per processor are typically seen in DCs of each size?

### *Small DC Market Decision Making*

In this section, we'd like to learn more about how decisions are made about purchasing IT and HVAC equipment.

28. Can you describe how IT decisions are typically made in small DCs? For example, who is the decision-maker, are there multiple decision-makers, and what is the process for:
    a. Decisions about equipment purchase?
    b. Decisions about virtualization?
    c. Decisions about migration to co-location or cloud?

29. Can you describe how HVAC decisions (i.e., about cooling, thermostat settings, humidification) are typically made in small DCs? For example, who is the decision-maker, are there multiple decision-makers, and what is the process?

30. What are the top priorities for customers when making decisions about their small DC? (Do not read; mark all that apply)
    a. Uptime and performance
    b. Cost
    c. Energy savings and energy efficiency
    d. Data security
    e. Innovation
    f. Space capacity
    g. Power and cooling capacity
    h. Other, please describe

31. Do these top priorities change by:
    a. Small DC Market Type (read selected relevant market type(s) from Question 6)?
    b. Small DC Size (greater than 1,000 and less than 1,000 square feet)?
    c. Organization Types (read selected relevant organization type(s) from Question 10)?

### *Current Purpose and Future of Small DC Market*

32. Why do businesses continue to use or rely on the following two DC types (e.g., are particular applications run or certain files stored locally):
    a. **Branch or satellite DC**, which is a branch office of a large bank whose main IT services may be provided via larger corporate DCs, co-location or cloud service?
    b. **A small server closet in a small to medium sized organization (SMOs)** whose main IT services may be **externally managed** via co-location or cloud service?

33. Do you think that the IT services provided by on-site small DCs will continue to be managed locally, or will they migrate to larger, centralized DCs (co-location, cloud, larger corporate DC)?
    a. If so, to what extent do you see them being migrated, and when?

34. Where do you expect the IT services provided by on-site small DCs to migrate? (do not read)
    a. Co-location facility
    b. Cloud computing services
    c. Larger corporate DC
    d. Other

35. Are there functions that will always be managed internally via an on-site small DC?
    a. If so, what are those?
        i. Why do you think they are so unique?

### *Closing*

Thank you very much for your time. Could you please let me know how you would like to receive the gift card (address)? We will be in touch to share our findings once the research has been completed. Also, are there other contacts that you have who would benefit from completing this survey and receiving the final report/market assessment?

Name:
Title:
E-Mail Address:
Mailing Address:
Additional Contacts:

CADMUS

# Appendix D. SDC Manager Interview Guide

## *Interview Introduction*

*PG&E and The Cadmus Group, a technical contractor to PG&E, are interested in obtaining information about the* ***small data center (DC) market and its energy efficiency opportunities. Small data centers include server closets, server rooms, and localized DCs that occupy space that is less than 1,000 square feet.*** *With this information, PG&E could develop a select package of incentive programs to encourage energy efficiency upgrades for the small DC space. This interview will take less than 20 minutes of your time today. We understand your time is valuable and as a token of our appreciation, if you complete the interview, we will send you a $25 Visa gift certificate or a donation in your name to a charity.*

**Organization Name:**
**Respondent Name:**
**Respondent Role:**

## *Customer Small DC Background Information*

36. Would you describe your small on-site DC/server room space (<1,000 square feet) as: (select all that apply)
    a. **Branch or satellite small DC**: a branch office of a large bank whose main IT services may be provided via larger corporate DCs, co-location, or cloud service (e.g., remote site data center; regional data center; local data center)?
    b. **A small DC in a small to medium sized organization** whose main IT services may be **externally managed** at a co-location or via a cloud service?
    c. **A single "full service" small DC of a small to medium organization** where all IT services are **internally managed** through an on-site (hosted) small DC?

37. About how many employees does your company have?
    a. Of those employees, how many are in northern California?

38. How large (in square feet) is your on-site[23] data center?
    a. Please provide us with the information below regarding all the DC spaces you manage:

| Size (square feet) | Location (On-Site*, Off-Site, or co-location) | Number of Servers |
|---|---|---|
| | | |
| | | |

*The remaining questions pertain to* ***your small on-site DC spaces*** *that we just discussed.*

## *Decision-Making*

*In this section, we'd like to learn more about how your organization makes decisions that affect your small on-site DC spaces.*

39. What is your role within your organization?

[23] On-site refers to the actual customer address we are calling.

40. Which parties, internal and external (e.g., VARs and service providers) to your company, are involved with small on-site DC spaces (< 1000 square feet) operations?
41. Can you describe the decision making process (i.e., who is the decision-maker, are there multiple decision-makers including external parties) around your small on-site DC spaces for:
    a. Decisions about equipment purchase?
    b. Decisions about virtualization?
    c. Decisions about migration to co-location or cloud?
42. Can you describe the decision-making process (i.e., who is the decision-maker, are there multiple decision-makers including external parties) for your small on-site DC spaces around HVAC decisions (i.e., about cooling, thermostat settings, humidification)?
43. What are your top priorities when making decisions about your small on-site DC spaces? (Mark all that apply)
    a. Uptime and performance
    b. Cost
    c. Energy savings and energy efficiency
    d. Data security
    e. Innovation
    f. Space capacity
    g. Power and cooling capacity
    h. Other, please describe
44. Who do you purchase DC equipment (controls/monitoring, racks/infrastructure, IT equipment) from? (Not just the OEM, but the sales channel)
45. Where do you get information about products and equipment?
46. Are there any other organizations that you have not yet mentioned that are involved with DC management or decisions?
    a. Would you be willing to provide their contact information?
47. To what extent are the previous companies involved with your decision-making?

### *Energy Efficiency Opportunities*

*In this section, we would like to understand more about the energy efficiency opportunities you pursued or could pursue in your small on-site DC spaces. By energy efficiency opportunity, we mean an equipment retrofit or upgrade that reduces energy use.*

48. How often does energy efficiency factor into your IT decisions?
    a. All the time
    b. Most of the time
    c. Some of the time
    d. Never
49. *Energy efficiency opportunities:* Please tell me if you are familiar with the technology and whether you have implemented it your small on-site DC spaces. Please tell me if you: have implemented, are familiar but have not implemented, or are not familiar and have not implemented.

j. Server virtualization/consolidation
k. Decommissioning of unused servers
l. Better data storage management
    a. Data storage consolidation
    b. De-duplicate data
    c. Thin provisioning
    d. Organize storage by tiers
    e. MAID
    f. Solid state storage
m. Purchasing energy-efficient servers and power supplies
n. Properly deployed airflow management strategies
    a. Blanking panels, grommets, and structured cabling
    b. Hot aisle/Cold aisle setup
    c. Containment enclosures: in row cooling, strip curtains, chimney cabinets
o. Variable speed fan drives on cooling equipment
p. Adjusting server inlet temperatures closer to the high end of ASHRAE recommended temperature range of 80 degrees F
q. Humidity adjustments
    a. Turn off humidifiers
    b. Broaden humidity range
    c. Install adiabatic systems (misters, foggers, ultrasonic)
r. Free cooling
    a. Air-side economizer
    b. Water-side economizer
s. Migration to the cloud

50. From the list that I just read, what 3 technologies have the most opportunity and potential to be implemented in your small on-site DC spaces? Please explain.

51. *(If no virtualization, SKIP)* What percentage of your small on-site DC spaces uses virtualization?

    a. Of your small on-site DCs that use virtualization, what percentage of servers is virtual?

    b. Why have you chosen not to virtualize all of your servers?

52. What are the main barriers to pursuing energy efficiency technologies or practices? (Mark all that apply)

    a. Risk averse: focused on uptime and performance
    b. Resource constraints
    c. Focus on initial/upfront cost rather than long-term payback
    d. Energy efficiency is not a priority
    e. Lack of standards and best practices
    f. Who pays the bill and who gets credit for cost-saving? Split incentives and complex decision-making involving facilities, IT, and external vendors
    g. Lack of understanding on the part of IT vendors
    h. Lack of understanding on the part of the in-house IT manager
    i. Lack of utility incentives that decrease upfront cost
    j. Other (please specify)

53. Can you comment on virtualization costs that you've encountered? How much does virtualization typically save or cost (when comparing the cost of purchasing new virtual hosts and licenses to the cost of purchasing additional non-virtual servers to cover additional capacity)?
54. Do you request or receive information about how to manage energy consumption?
    a. What information or resources might help you pursue energy efficiency upgrades? What type of utility incentive programs would you find to be helpful?

### *IT Load and Operations*

55. About how much of your total energy do you think the DC uses?
56. Can you estimate how many server racks, servers per rack, and KW per rack?
57. Can you estimate the number of processors per server and number of cores per processor typically purchased?
58. What type of temperature and humidity control systems do you have (prompt, if necessary: thermostat, where is the temperature measured to control whole room)?
59. What are your server inlet temperature settings?
60. How often do you replace your servers (years)?
    a. Why are they refreshed at that rate?

### *Current Purpose and Future of Small DC Market*

61. Do you think that your on-site IT services will continue to be managed locally, or will they migrate to larger, centralized DCs (co-location, cloud, larger corporate DC)?
    a. If so, to what extent do you see them being migrated, and when?
62. Where do you expect the IT services provided by your on-site small DC spaces to migrate?
    a. Co-location facility
    b. Cloud computing services (When will they go to the cloud?)
    c. Larger corporate DC
    d. Other
63. Are there functions that will always be managed internally via an on-site small DC spaces?
    a. If so, what are those? Why do you think they are so unique?

### *Closing*

Thank you very much for your time. Would you mind giving me your mailing address so I can send you the gift card? Also, are there other contacts that you have who would benefit from completing this survey and receiving the final report/market assessment?

| Name | Title | E-Mail | Mailing Address | Additional Contacts |
|---|---|---|---|---|
| | | | | |

## Appendix E. Increasing Completion Rates with SDC Managers

While completing this project, Cadmus made every effort to be as cost-effective and efficient as possible when reaching out to IT vendors and SDC managers. In addition, Cadmus staff has notable experience administering interviews to industry stakeholders and customers, and tested successful and proper strategies and tactics were employed to increase SDC manager and IT vendor interview uptake and completion.

It was important to stay within budget and follow the timelines, and as this project unfolded, it became clear that reaching this market was a challenging task to complete within the established project scope. As a result, the interview outreach was stopped when budget and timeline were exhausted. Cadmus uncovered a number of lessons learned when contacting this market that can help abet future studies targeted toward this customer segment.

1. **Pursue larger customers.** Customers with more employees and a larger IT infrastructure are more likely to have dedicated staff and resources, and the knowledge and time to complete the interviews. Many of the customer contacted during this study had fewer than 50 employees because they SMB market was the target of this research.
2. **Shorten interview length.** Completion rates were higher (~31%) with the brief SMB customer survey than with the longer 30-minute SDC manager interview (~3%). If content can be sacrificed, consider shortening the interview guide length.
3. **Focus on specific NAICS codes.** This study found that Government, Schools, Healthcare, Offices, and Manufacturing & Transportation NAICS codes had a higher likelihood of having SDCs. If the objective of the study is to obtain information about existing and operating SDCs and their characteristics, targeting customers within specific NAIC codes may prove more fruitful.
4. **Consider an online option.** Follow-up with the targeted customers would be necessary, but attempting to reach customers via e-mail and an online survey would decrease staff time to administer the survey and allow that budget to be used for greater, more expansive outreach and follow-up. In addition, data input and analysis may be more streamlined. With this option, e-mail addresses of the correct contact within each organization would be mandatory.
5. **Attend conferences and trade shows.** Instead of completing cold calling, it may be successful to have staff attend live conference and trade shows to speak directly with SDC managers and other IT staff.

# Appendix F. IT Load Estimate Thought Exercise

As shown in the results of the SMB customer survey (see Table 1), certain types of industries are more likely to have an SDC. Additionally, PG&E provided data on the actual number of SMBs as a function of NAICS code. With this data, Cadmus performed the following exercise:

- Roughly estimated the number of SDCs in SMBs in PG&E's territory. Cadmus multiplied the percentage of NAICS coded industries with an SDC by the number of SMBs in the NAICS coded industry. This estimate resulted in 255,229 SDCs in SMBs in the PG&E territory.[24]
- To complete an SDC server load estimate, Cadmus multiplied the number of SDCs by:
  - 185 watts per two-processor server[25]
  - Three servers per SDC (median of servers per on-site SDC)
  - The distribution of servers by NAICS code

When using the assumption that the average SMB has three servers in its SDC, Cadmus calculated that SDCs represent 12% of PG&E's SMB energy use. If we use the assumption that each SMB has a data center closet with just one server, the PG&E SMB energy load decreases to 4%. Table 4 shows more details for these estimates.

**Table 4. SMB Server Load and Energy Use Estimate Exercise**

| Servers per SMB (Median=3) | SMB Server Peak Demand across PG&E Territory (MW) | SMB Server Energy Use across PG&E Territory (GWh) | Percentage PG&E SMB Peak Demand | Percentage PG&E SMB Energy Use |
|---|---|---|---|---|
| 3 | 142 | 1,242 | 4% | 12% |
| 1 | 47 | 414 | 1% | 4% |

[24] Based on data provided by PG&E.

[25] Based on unpublished analysis of EPA ENERGY STAR data set of server energy use.