From Our Closet to Yours: Fashioning Energy Efficiency Programs for Small Data Centers

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ABSTRACT

Small data centers (SDCs), defined as having less than 1,000 square feet of white space,[1] are believed to have a large untapped energy savings opportunity. More than half of the servers in the U.S. are located in SDCs, and they can represent a large proportion of the total energy use of many commercial establishments. How large, where these are located, and how to best tap their energy savings opportunities is the focus of the research for this paper.

Even though most commercial and industrial buildings contain SDCs, the savings opportunity per SDC site is very small compared to the enterprise DCs that usually benefit from energy efficiency incentives. Also, deciding what options are best is complex for this market. To improve our understanding of the SDC market and its energy-efficiency opportunities, we initiated a study that involved:

- In-depth interviews with information technology (IT) value-added resellers, service providers, and system integrators serving SDCs;
- Telephone surveys of hundreds of business customers to establish SDC presence; and
- In-depth interviews with SDC managers and consultants.

Energy savings can be realized through IT measures such as server virtualization, uninterruptible power supplies, data storage management, and energy-efficient servers. Midstream incentives targeted toward vendors or upstream incentives targeted at the manufacturer may prove most effective. Select data center services can readily move to "the cloud" (Internet) or co-location facilities, but for the present most SDCs will remain an end-use market for security and bandwidth reasons.

Introduction

From 2005 to 2010, electricity use by data centers increased by about 56% worldwide and by about 36% in the United States (Koomey 2011). Despite recent efficiency gains, data centers consume a significant and growing amount of energy—currently 2% of the electricity in the United States (Koomey 2011). Worldwide, data centers use about 30 billion watts of electricity, which is roughly the equivalent of the output of 30 nuclear power plants. Estimates indicate data centers in the United States account for 25% to 33% of that load, the estimates show. Industry analysts estimate the North American data center market power consumption is 11.55 GW, which is an increase of 6.8% over 2013 estimates (Data Center Dynamics 2014).

[1] White space is generally defined as the total square footage inside the cooling envelope and includes server and storage racks, power supplies, and space between racks.

With this increase in consumption, the opportunities to save energy in data centers are tremendous. The U.S. Department of Energy estimates reductions in energy use could be as high as 80% between inefficient and efficient data centers (U.S. Department of Energy 2011).

Historically, utility programs have had difficulty achieving cost-effective energy-efficiency savings in SDCs. This is because the market, although extensive, is disaggregated and hard to reach and the savings per efficiency project are traditionally quite small. Nevertheless, SDCs are a vast untapped efficiency market, representing 50% of all servers in the United States (Bailey et al. 2006), as noted in recent studies. The Natural Resources Defense Council and the U.S. Department of Energy believe that program implementers can increase energy-efficiency opportunities for SDCs through education, evaluation tools, and onsite efficiency evaluations (Bennett and Delforge 2012, Tschudi 2012). 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 (Bramfitt and Delforge 2012).

Methodology

In 2013, Pacific Gas and Electric Company (PG&E) tasked Cadmus to study the energy-efficiency opportunity in SDCs in its service territory, by focusing particularly on small and medium business (SMB) customers.[2] This research obtained additional information about these specific segments of the untapped SDC market:

- 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) (Bailey et al. 2006)

Cadmus, along with PG&E, designed a survey that asked businesses about SDC size, location, function, decision-making, managers' attitudes toward energy efficiency, energy-efficiency barriers and opportunities, virtualization, migration to cloud and co-location, and IT loads. The research involved the following tasks:

- **In-depth informational interviews with IT vendors:** Cadmus carried out 18 interviews with IT vendors to characterize the three SDC market segments. Cadmus interviewed equipment manufacturers, value added resellers, IT service providers, and system integrators in PG&E's service territory. The vendors ranged in size from one employee to 350 employees and serviced all of the data center market sizes.
- **Surveys of SMB customers:** Cadmus obtained information from over 320 customers through a short survey that asked about the prevalence and size of SDCs (either the number of servers or the square footage) and the industry type of the company surveyed. Responses to this survey 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.
- **In-depth informational interviews with SMB SDC managers:** Cadmus conducted in-depth interviews with 34 SMB SDC managers (who oversaw both IT and facility

[2] 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 less than 200 kW for at least nine billing periods over the past 12 months.

operations). The interviews examined energy-efficiency opportunities, decision-making within SDCs, attitudes towards energy efficiency, and future direction of the SDC. Given the limited number of interviews with SDC managers, this information should be seen as preliminary for guiding future efforts directed at the SDC market.

Major Findings

This study gained information about the SDC market, such as what decisions managers make about SDCs, their attitudes towards energy efficiency and how they implement energy-efficiency measures, the future of SDCs, and the design of programs targeted toward this customer segment. The major findings are discussed below.

SDCs are Pervasive (Many Have Closets to Store Their Clothes)

Through surveys with approximately 320 SMBs[3], Cadmus found that roughly half reported use of SDCs. Also, many different market segments have SDCs. The government sector had the highest percentage of respondents with SDCs (87%), followed by schools (75%), healthcare (62%), and offices (56%). The respondents were located primarily in California: in San Francisco, the Central Valley, and the Silicon Valley. Table 1 shows the percentage of respondents within each sector that had an SDC.

Table 1. Survey results of SMBs regarding presence of SDC (n=321)

Market Segment	Total Respondents	Percentage of Total Respondents	Number of Sites with an SDC	Percentage of Sites with an 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%
Total	**319**		**152**	**48%**

The SDC managers oversaw SDCs server rooms, server closets, localized data centers, and services in the cloud. The breakdown of interview respondent is shown in Table 2.

[3] The number of employees varied at the organizations' interviewed. Slightly more than half (18) of the 34 SMB customers were organizations with fewer than 50 employees. However, five SDC managers worked for organizations with more than 1,000 employees.

Table 2. Survey results of SMBs regarding SDC type (n=34)

Number of Server Per Small DC	SDC Type Count	Percentage
Server Closet (less than 200 sq. ft.)	19	59%
Server Room (200 to 499 sq. ft.)	10	31%
Localized DC (500 to 1000 sq. ft.)	3	9%
Cloud Services Only	2	6%

We found that SDC managers were hard to reach; they have limited time and a myriad of responsibilities. IT vendors were much easier to reach and were, in general, more willing to make themselves available than SDC managers.

IT Vendors are Very Influential (Like Anna Wintour)

IT vendors were key contributors to decisions made about SDCs and were used by 14 out of 31 SDC managers to assist with operations. The process for selecting IT equipment was described in this manner:

1. IT vendors provide information, recommendations, and quotes to customers.
2. An internal IT manager, IT director, or vice president (VP) is often involved in making the decision and grants final approval of the products and system to install.
3. A vice president (VP), chief financial officer (CFO), or a chief executive officer (CEO)/president/owner gives final budget approval.
4. SDCs usually purchase their IT equipment from OEMs, retailers, and the IT vendor for their purchases.

SDC managers generally do not make the purchasing decision for cooling equipment; although 16 out of 31 stated they were "involved" in the process. Instead, facility managers make decisions regarding SDC cooling using the same decision making process detailed above for IT equipment but using funds from the budget allocated for facility improvements. Of the 16 SDC managers involved in the HVAC purchase, eight stated that they could control temperature and humidity in their SDC and the remainder used the building's general settings, which is expected given the higher percentage of server closets in the sample.

SDC Priorities (Do They Care More About the Shoes or the Hair?)

The importance of energy efficiency varies by the SDC manager. As shown in Figure 1, more than 60% of SDC managers reported considering energy efficiency when making IT purchases. SDC managers typically responded, "Yes, whenever possible (if it makes economic sense)." However, 67% reported that they do not request information about energy efficiency and 77% do not know the IT load at their business. These two responses conflict slightly and may indicate self-report bias.

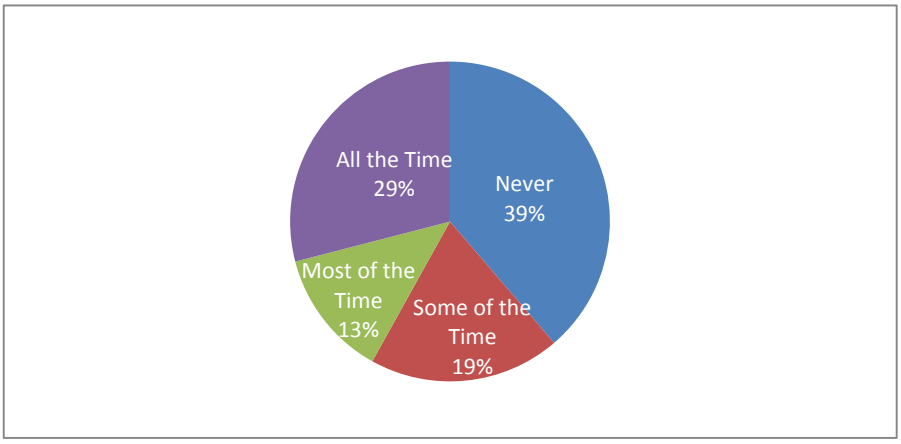

Figure 1. Frequency that energy efficiency factors into IT decisions (n=31).

As shown in Figure 2 and Figure 3, attitudes towards energy efficiency improved as the size of the SDC (reflected by the number of servers) or organization (reflected by the number of employees) increased.

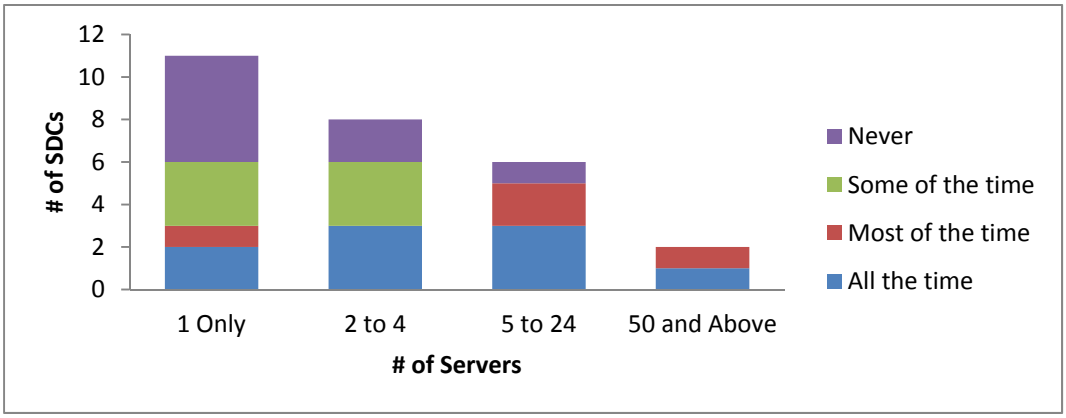

Figure 2. Frequency that EE factors into IT decisions by number of servers (n=27).

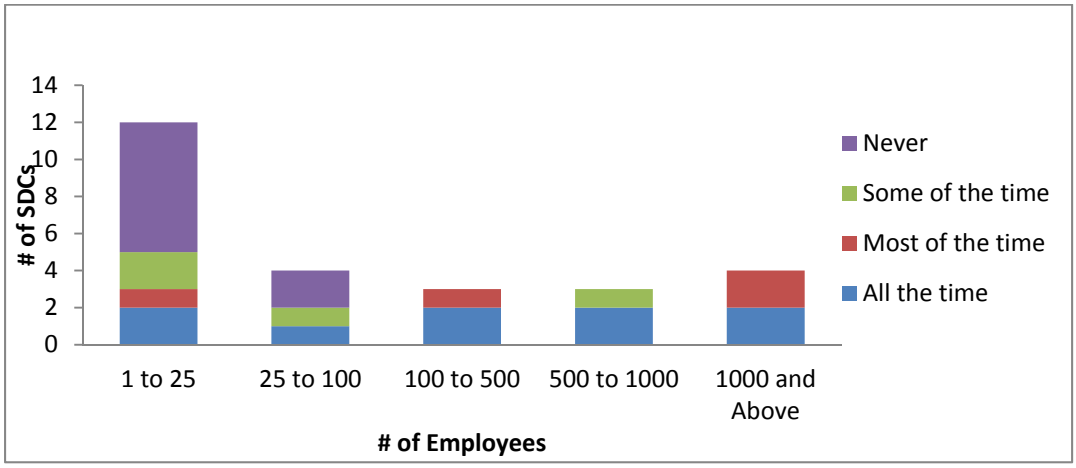

Figure 3. Frequency that energy efficiency factors into IT decisions by number of employees (n=26).

In contrast to the results of the interviews with SDC managers, IT vendors reported that their SDC customers seldom ask about energy efficiency when discussing improvements to their SDCs: 35% "never" ask about energy efficiency, 29% "rarely" ask about energy efficiency, and 18% "sometimes" ask about energy efficiency. Only 6% "always" and 12% "often" ask about energy efficiency. These results are shown in Figure 4. We believe self-report bias may have occurred with both the IT vendors and SDC managers with this question due to the responses to other interview questions.

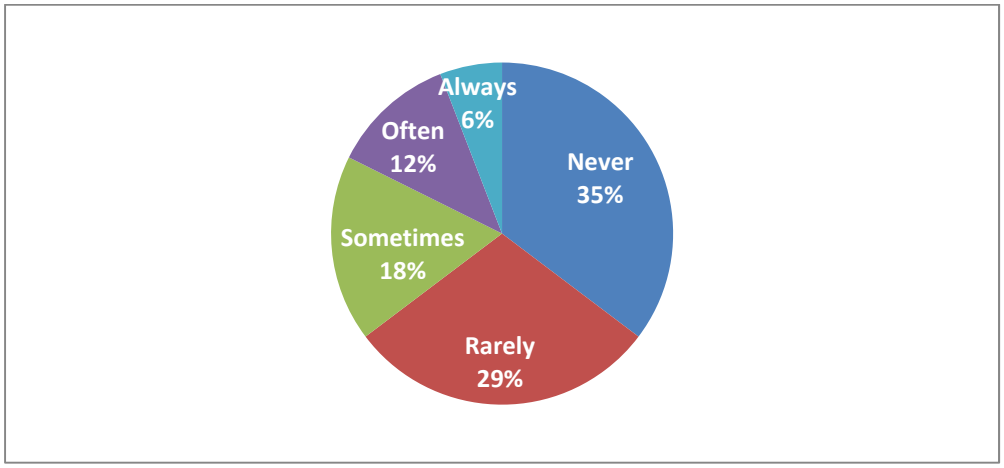

Figure 4. How often do IT vendors' SDC customers ask about energy efficiency? (n=17).

The top priorities for SDC managers were very similar to those revealed in the interviews with IT vendors. Figure 5 shows the priorities for both groups. Uptime and performance, cost, and data security (e.g., compliance with Sarbanes-Oxley and HIPPA) were the top three priorities; energy savings and efficiency, space capacity, and innovation were the least popular answers.

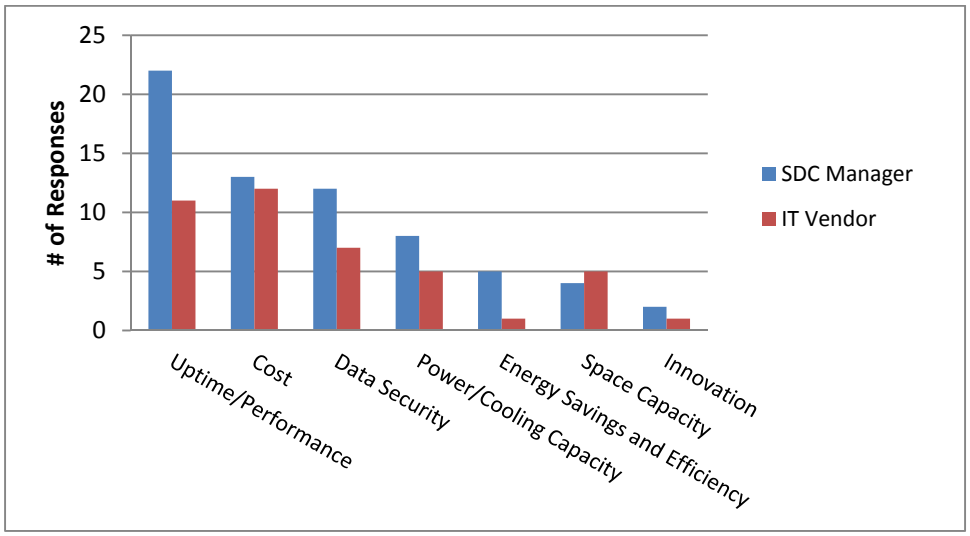

Figure 5. Top priorities for SDC managers and IT vendors (multiple selections possible; n=33 for managers, n= 17 for IT vendors).

Existing Energy Efficiency Measures (What Is Everyone Wearing Now?)

Implemented efficiency measures tend to be IT equipment-focused, rather than HVAC-focused. This is likely a product of the fact that SDC managers are not responsible for facility upgrades. As shown in Figure 6, SDC managers indicated that the IT efficiency measures most often implemented are energy-efficiency servers and uninterruptible power supplies (UPSs) (62%), decommissioning of unused servers (62%), data storage management (47%), and server virtualization (47%). There are few 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.

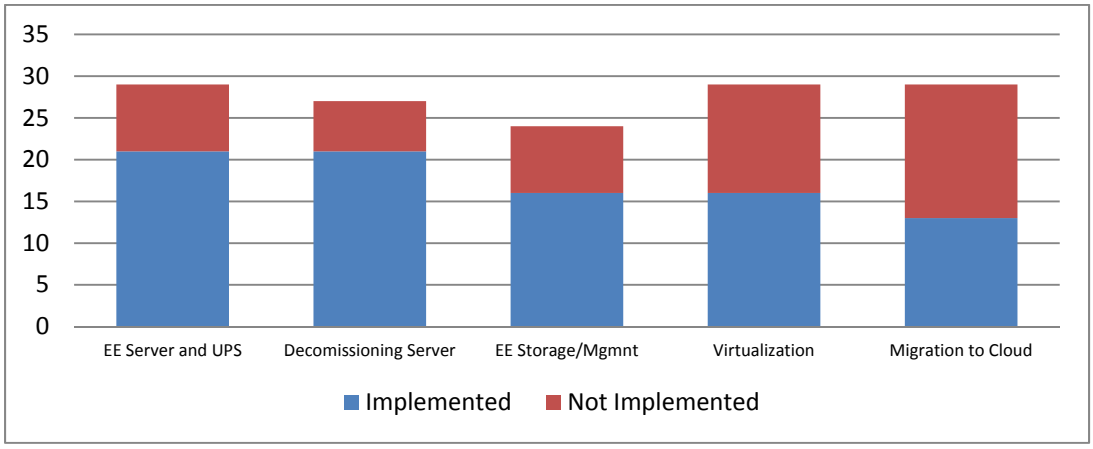

Figure 6. Implemented energy-efficiency measures (n=32).

Energy-Efficiency Barriers (What Style Risks Are They Unwilling to Take?)

IT vendors and SDC managers ranked resource constraints as the top barrier that prevented SDCs from investing in energy efficiency. Table 3 compares both groups' top five barriers preventing energy-efficiency measure implementation.

Table 3. Top five barriers to energy efficiency

Rank	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 education of in-house IT manager
4	Lack of education of in-house IT manager	Risk averse
5	Risk averse	Energy efficiency not priority

The specific narratives from the SDC managers varied. Some indicated their SDC's energy footprint was not large enough to warrant focus, others said they did not have enough information about available energy efficiency opportunities, and, finally, others mentioned there were few, if any, complications associated with energy efficiency initiatives. The barriers did highlight that lack of funding is a serious concern for SDC managers. The results of the survey and interviews 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.

These barriers highlight that there is a difference between large data centers and SDCs. Large 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 must rely on the building's existing HVAC system. Due to greater flexibility and additional access to capital, IT managers at larger data centers tend to be more concerned about the energy efficiency of their facility.

Best Energy Efficiency Opportunities for SDCs (What is on The Runway?)

When asked which three energy-efficiency opportunities would have the highest potential of implementation in SDCs, SDC managers and IT vendors placed virtualization, data storage management, and migration to the cloud as the top three, as shown in Table 3. Some IT vendors acknowledged that, although server virtualization is the measure they most often see implemented, it also 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.

Table 3. Survey results of SDC manager and IT vendor "Best" energy efficiency opportunities

Energy Efficiency Measure	SDC Manager Response	IT Vendor Response
Server Virtualization	38%	26%
Data Storage Management	16%	24%
Migration to the Cloud	13%	23%

All responses recorded from the SDC managers are shown in Figure 7. No respondents mentioned humidity controls or free cooling as energy efficiency opportunities.

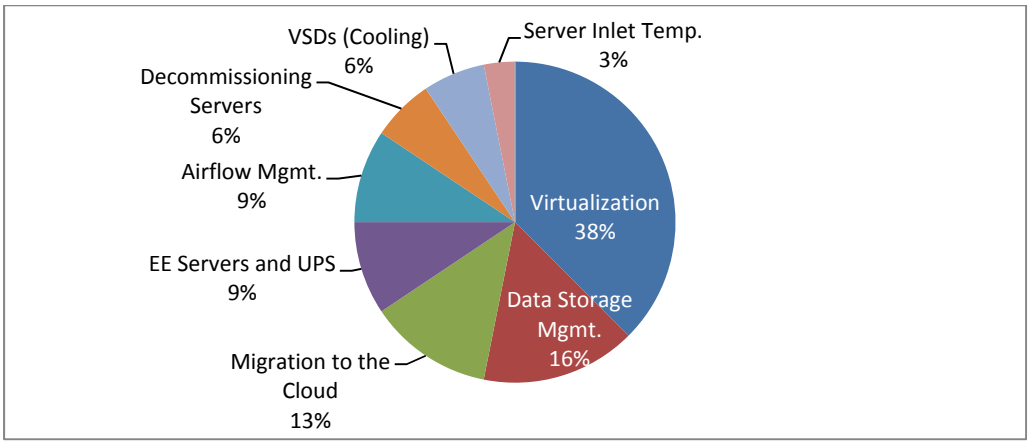

Figure 7. Top energy-efficiency opportunities (multiple selections possible; n=17).

Since migration to the cloud or a co-location facility is cost-effective and popular for SDCs, we confirmed that the SDC would continue to exist as a potential energy-efficiency market. IT vendors and SDC managers indicated that the SDC market still existed and that SDCs are kept onsite because of inertia; security requirements; reliability (not dependent solely on connectivity); and enhanced speed/performance. Some applications will likely always be stored locally, including high security data, phone services, and file and print servers.

Satellite Offices

We targeted questions to assess whether satellite SDCs of large corporations would be more efficient (e.g., adopting or required to deploy best efficiency practices stemming from influence of the large corporate data center). IT vendors who worked with both stand-alone SDCs and satellite offices indicated that, in general, satellite offices operated independently from their larger corporate headquarters so these spaces would have characteristics and opportunities similar to stand-alone SDCs.

Virtualization

Virtualization was less common in SDCs than in large data centers. Sixteen of 29 SDC managers reported using virtualization, and IT vendors estimated that 69% of their SDC customers use it. Nine of the 16 SDC managers who had implemented virtualization said 45% of their servers were virtual servers. According to 13 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. IT vendors indicated the following about server virtualization:

- Organizations have implemented virtualization projects with as few as two servers.
- The average refresh rate of servers is four years. This aligns with the 21 responses from SDC managers who reported that the average server refresh rate was six years (with a minimum of a refresh every two years and a maximum of every 15 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."
- 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."
- Customers were virtualizing on their own (without assistance from utility programs or without much encouragement from vendors). This signals a possibility for freeridership.

Cloud and Co-Location Migration

SDC managers cited some drawbacks around migrating to the cloud or moving to a co-location facility. SDC managers reported their organizations remain concerned about the security

of managing their data at offsite locations; the speed with which systems can transfer and deliver data; and the ability to control, manage, and oversee their physical servers. SDC managers and IT vendors speculate that onsite SDCs will be used for the foreseeable future because they believe these centralized infrastructures do not have the necessary level of information security or bandwidth to keep SDCs' businesses operating safely and smoothly.[4]

According to IT vendors, certain industries (e.g., financial services, banks, and hospitals) will have trouble using only cloud services because of data security issues. Also, those that need high bandwidth will maintain their servers at local brick and mortar locations and will not move data to the cloud unless technology improves. The SDC managers offered a different perspective when asked where onsite SDC services may migrate. Fifty-five percent responded that they would not migrate, 31% would migrate to the cloud, 10% to a co-location, and four percent to a larger corporate data center.

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 SMBs in PG&E's territory.

Strategically Incentivize Efficiency Measures (Teens Own Skinny Jeans, but Do Adults?)

Alleviate resource constraints. Resource constraints hinder energy-efficiency measure implementation. The influence of energy efficiency increases with size of the data center. As the number of servers or employees went up (which likely increases an SMB's access to resources), the importance of energy efficiency in decision-making went up. Properly targeted incentive programs can alleviate the lack of funding and high upfront cost typically associated with energy-efficiency upgrades.

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 smaller facilities.

ENERGY STAR® is releasing new specifications for UPSs, storage, and servers. The ENERGY STAR specification for storage requires that storage units be sized to accommodate advanced storage management utilities. Utilities should consider prescriptive incentives that incorporate these specifications.

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

Therefore, we recommend that utilities target a server virtualization program and provide education, services, and incentives to the customer groups that are less likely to complete virtualization on their own. It is important to remember that server virtualization presents a high

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

risk of freeridership, unless handled properly. Prior to launching a program, program administrators can meet with evaluators to plan the program and performance expectations, thereby reducing risks associated with freeridership. They should also review the latest evaluations that offer analyses of data center programs.

Explore migration to cloud or co-location services. Program administrators 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. In fact, utility programs exist where customers are offered incentives for moving to the cloud or to a co-location facility. One program administrator is providing SDCs with an incentive for migrating to the cloud. This program design model may prove cost-effective and successful in certain utility territory.

Develop a Program Design that Follows the Market (Find the Trendsetters)

Target IT Vendors, OEMs, and Retailers. IT vendors often play a large role in the decision-making process at SDCs. As a result, program administrators 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 difficult to reach and often do not incorporate energy efficiency into their decisions.

If incremental costs and energy savings are low, the incentive can be targeted midstream to the supplier or vendor because it may be more effective to engage the marketplace with midstream or upstream incentives. Successful midstream and upstream programs typically involve the collaboration of multiple efficiency programs for a larger customer base in order to attract vendor participation and possibly manufacturer interest (e.g., leading server manufacturers that sell directly to customers).
Given the difficulty of reaching SDC managers and the recommendation to use prescriptive rebates, any SDC program should target IT vendors or use an upstream approach to target OEMs and retailers (similar to the business and consumer electronics model).

Conduct Additional Research. It might be effective to complete a pilot assessment to determine the potential for efficiency in SDCs. Program administrators should consider the following when implementing a pilot effort:

- Test different outreach techniques to reach SDC managers
- Confirm specific efficiency measures
- Examine alternative program designs
- Quantify energy savings through metering

Conclusion

SDCs remain a viable and important market for energy efficiency opportunities. Upfront costs of IT equipment can be offset with prescriptive incentives to make efficient equipment more accessible for resource-constrained SDCs. IT vendors are very influential in this market so it may be effective to implement mid- or upstream energy efficiency programs to provide

additional incentive for IT vendors to promote efficient products. Finally, operations are moving to the cloud or co-location facilities so consider incentives for migration to the cloud or conduct research to understand how the trends in this market will affect different service territories.

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