Small Server Rooms, Big Energy Savings

Opportunities and Barriers to Energy Efficiency on the Small Server Room Market

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About NRDC

NRDC (Natural Resources Defense Council) is a national nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at www.nrdc.org.

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EXECUTIVE SUMMARY

S mall server rooms house over half of all computer servers in the United States, accounting for approximately 1 percent of all electricity use in the country. Administrators of server rooms have been slow to adopt best practices in energy efficient operations, despite the fact that server rooms represent a large share of data centers' electricity use. A new survey by the Natural Resources Defense Council (NRDC) suggests this gap is poised to increase over the coming years without policy intervention.

The NRDC estimates that energy waste in U.S. server rooms and closets represents the equivalent output of 7 medium-size coal-fired power plants (500 MW) and costs U.S. businesses over $2 billion per year in electricity costs. Yet most of the attention of the market on energy conservation is focused on large data centers, which are easier and more profitable to address.

Technologies to significantly reduce energy waste in server rooms—such as virtualization, power management, and cloud computing—are very cost-effective, and are already broadly deployed in other market segments. These technologies provide many business benefits other than energy savings. In small server rooms many of the same benefits are available, but the opportunity is often missed because of a lack of information, expertise, time, or incentives.

States and utilities can help to stimulate this large yet hard-to-reach market through incentives, marketing, and outreach, as well as training and education programs for IT managers of small server rooms and the IT service provider firms that support them.

I. BACKGROUND

Data center energy consumption is growing rapidly. Data center electricity use is one of the fastest-growing areas of energy growth in the U.S. economy, comprising approximately 2 percent of U.S. electricity use.[1] The growth of cloud computing and the explosion of data being stored and transferred is expected to vastly increase total data center carbon emissions in the next decade.[2]

NRDC is looking for ways to mitigate the environmental effects of this rapidly growing sector. One of the opportunities is to adopt best practices in energy-efficient operations in small server rooms.

> *Data center electricity use is one of the fastest-growing areas of energy growth in the U.S. economy*

Small server rooms are not making as much progress on efficiency as large data centers. Managers of large data centers have begun to implement efficiency best practices for servers, such as server virtualization[3], hardware efficiency, and streamlined cooling systems. In large installations, the energy cost savings and performance improvements of these upgrades are large enough that the markets have begun to address them.

Large, mid-tier, and enterprise-class data centers comprise only half of all U.S. servers. The other half are housed in the small server rooms and closets typically found in small and medium businesses and organizations, as well as in departments and branch offices of larger organizations. NRDC estimates that poor operational practices in U.S. server rooms and closets lead to the waste of over 20 billion kWh annually, the equivalent output of 7 medium-sized, coal-fired power plants (500 MW). This wasted electricity costs U.S. businesses over $2 billion per year. Yet most commercial energy-saving products and services are aimed at large data centers, which are easier and more profitable to address.

For smaller server room operators, we hypothesize that considerable market barriers still exist and are limiting the adoption of cost-effective, energy-saving server technologies. Our preliminary calculations suggest that virtualization can be a cost-effective investment for as few as five servers, and can reduce server room energy use up to 80 percent. We do not believe that these opportunities are being exploited to their potential in the small server room market.

The NRDC survey was designed to provide insight into three areas:

- How much are small and medium-sized companies using energy-saving virtualization and cloud computing?

- What are the barriers keeping these organizations from adopting virtualization and cloud computing?

- How important are energy use and energy bills in IT decision making for small and medium-sized businesses?

We focused on virtualization and cloud computing because they are arguably the largest and most cost-effective savings opportunities in server rooms. The average U.S. server operates at only a 5 to 15 percent utilization level while consuming 60 to 90 percent of its maximum system power, according to an EPA report to Congress in 2007. Virtualization increases server utilization while dramatically reducing energy use.

Cloud computing can provide even higher utilization efficiency. It can spread the efficiency across multiple customers. Cloud computing is typically operated in highly efficient data centers, even though some of these efficiency gains can be offset by increased network consumption. The efficiency of cloud computing, of course, depends on cloud operators' data center efficiency and carbon intensity.

II. METHODOLOGY

The NRDC team developed a set of questions for IT managers. These questions addressed various issues related to their current server fleet, virtualization practices, cloud computing, obstacles to implementing efficiency improvements, energy use, and billing.

We conducted several surveys ourselves, and also partnered with Stanford University's "Stanford Environmental Consultants" student group, who conducted a number of additional surveys. Half of the surveys were conducted via telephone; the other half were online surveys where participants filled out the questionnaire using Google Forms.

Responses came from businesses and organizations in many fields: consulting, law, telecommunications, online advertising, public radio, biopharmaceutical, architecture, local government, religious organizations, non-profits, and education.

In total, we gathered 30 survey responses which met our criteria of between 1 and 100 servers. The survey was carried out between September 2010 and June 2011. Some of our survey questions were answered in sentence form, and we categorized these responses using our discretion.

Responses came from businesses and organizations in a broad spectrum of fields, including consulting, law, telecommunications, online advertising, public radio, biopharmaceutical, architecture, local government, religious organizations, non-profits, education, and many others. While we surveyed mostly small and medium businesses for this study, we also included some branch offices of large organizations that house small server rooms. It is beyond the purpose of this paper to identify the differences and similarities between those two decision-making environments, though certainly both large and small companies face barriers to adopting efficient practices in small server rooms.

Given the modest number of survey responses and the wide range of economic sectors included, we do not claim any findings to be statistically significant, but rather indicative and informative as we develop our advocacy efforts in this space. The large range of responses helped us to identify market barriers for specific industries, and also to see which issues may be universal across markets.

The organizations interviewed ranged from 3 to 750 employees in the local office where the server room was located, along with some organizations with thousands of employees worldwide. The range in number of servers also varied, from 1 in a small church organization to 55 in a department of a state university.

Some companies hosted all their servers off-site, and 13 percent of all respondents owned zero servers, running their whole operation in the cloud by leasing server compute cycles from vendors like Amazon EC2 and Rackspace.

III. SURVEY RESULTS: LESSONS LEARNED

1. SMALL AND MEDIUM-SIZED BUSINESSES OPERATE SERVERS IN A VARIETY OF OWNERSHIP CONFIGURATIONS THAT MAY MAKE EFFICIENCY UPGRADES CHALLENGING

■ 13 percent of respondents do not own servers and operate exclusively using cloud computing services

■ 20 percent of respondents use at least one server in the cloud

■ 23 percent of respondents either rent servers at an off-site location or host their own servers at a co-location.

While organizations using cloud computing are likely to be using very efficient servers—providers such as Amazon EC2 and Rackspace have strong financial incentives to make their large server fleets as efficient as possible—hosting a server at an off-site location may not be as efficient due to a classic misalignment of incentives. If the company decides which hardware to lease or purchase, but the host pays the electricity bills at the off-site location, the server operator does not have a financial incentive to optimize the energy efficiency of its servers. This split-incentive situation is similar to the owner-tenant problem so common in commercial buildings.
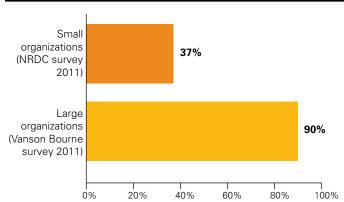
2. INDICATORS OF VIRTUALIZATION ADOPTION BY SMALLER BUSINESSES LAG BEHIND LARGER ONES

A 2011 survey of large companies' virtualization practices conducted by the market research firm VansonBourne[4] shows that most companies have tried virtualization and plan to do more in the future, but still have progress to make before achieving deep transitions to a mostly virtual server fleet (see Figure 1).

Our survey's results revealed starkly different results, especially in the percentage of companies that have tried virtualization and the percentage that plan to use or increase virtualization in the future.

Whereas 90 percent of large enterprises have virtualized at least one server, only 37 percent of small companies have done so. This shows that there is still a lot of education and marketing to be done to this sector.[5]

Figure 1: Use of Virtualization – Small vs. Large Organizations

When they do use virtualization, small organizations tend to implement it more broadly than large ones, which narrows the penetration gap to 11 percent. However, there remains a large untapped virtualization opportunity in both markets, and particularly in small and medium-sized businesses, where only 26 percent of all server stock has been virtualized.

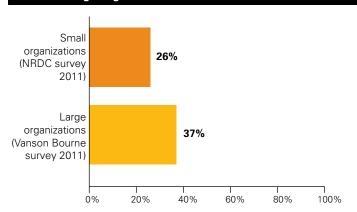**Figure 2: Virtualization Penetration Rate Over Server Stock: Small vs. Large Organizations**
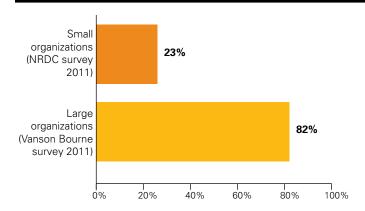

Figure 3: Plan to Increase Virtualization in Next 12 Months: Small vs. Large Organizations

The large enterprise market appears to be poised for high virtualization adoption. Almost all companies have now experimented with virtualization, and many say they plan to increase its use in their operations. This will increase the virtualization penetration rate in the figure above. In contrast, only 23 percent of small companies said they plan to increase their virtualization in the next 12 months, implying any of several barriers to adoption that may include lack of information, misaligned incentives, lack of capital, or prioritization for scarce capital.[6] Unless something is done to encourage small businesses to adopt virtualization, we may see virtualization penetration rates continue to remain low in that segment.

3. SMALL COMPANIES HAVE NOT ADOPTED VIRTUALIZATION BECAUSE OF UNALIGNED INCENTIVES AND LACK OF INFORMATION

Percent of organizations that do not pay their utility bill based on kWh (e.g. full service leases which include a fixed fee for utilities)	54%
Percent of organizations whose IT reps do not have regular access to the utility bill or building-wide energy consumption data	58%
Percent of organizations that do not have ready access to server electrical consumption data	93%

Barely half of small server room respondents pay for the energy they consume. If an organization is on an all-you-can eat energy plan, it loses the valuable business argument to adopt technologies and practices that reduce energy consumption.

Currently, 60 percent of the people that make server purchasing decisions do not have access to their company's energy bill. This is critical, as server rooms can account for anywhere from 30 to 70 percent of an organization's electricity consumption (particularly in office-based organizations). Because over 90 percent of organizations do not have a way of monitoring server room electrical use, this opportunity is being overlooked as a strategic way to seriously reduce overhead costs and environmental impact.

4. HALF OF ALL ORGANIZATIONS SURVEYED PLAN ON A SERVER ROOM UPGRADE NEXT YEAR

The finding that half of organizations surveyed plan on upgrading a server room in the coming year demonstrates how often there are opportunities for decision-makers to consider adopting efficient server technologies. Piggy-backing onto other upgrade decisions could be one way to start the conversation with IT managers. In particular, replacement of servers coming to the end of their warranty is the most cost-effective way to implement efficiency best-practices since project benefits include the cost avoidance of investing in 1-for-1 server hardware and software replacement.

IV. SURVEY RESULTS: BARRIERS AND OPPORTUNITIES

Barriers to cloud use are more psychological than real

Many of our survey respondents, when discussing barriers to using the cloud, said that a few of the barriers were actual, but most were based on lack of appreciation for the benefits of using energy-efficient server technologies and solutions.

Corporate inertia, lack of attention held energy efficiency back

A common obstacle to adopting new energy-efficiency technologies was simply corporate inertia and devoting attention to other business priorities over energy savings. New technologies require proposals, planning, approvals, and time. Some of the IT managers surveyed knew the benefits of the new technologies but simply hadn't made the time to adopt them, or had not been able to convince their management that the required investment was worth prioritizing.

Some companies are concerned about privacy

In a small number of industries, companies had significant restrictions on their ability to adopt cloud computing and virtualization. Law firms and healthcare organizations have concerns about data security. A state university department reported that it had financial restrictions on how it could share infrastructure; because it couldn't share servers with other departments and didn't have enough servers itself to virtualize, the value of virtualization was eroded. The same department reported that it is not allowed to send data outside the university without a signed business agreement, prohibiting a significant adoption of cloud computing. This is not the norm, but anyone creating programs should be sensitive to these kinds of restrictions for large institutional customers.

Companies are more aware of software costs than energy costs

Some respondents said the cloud is easier to scale, as new resources can be provisioned to expand capacity within minutes rather than days in an on-premise situation. Cloud also saved them from having to back things up as this is part of the cloud service. Although 63 percent of organizations surveyed have at least one application in the cloud[7], there are still many reservations about moving further into the cloud. None of the organizations surveyed listed saving energy as a main driver behind their choice to move to the cloud. Performance and cost of software were the main drivers.

Uncertainty about data security is the most common barrier

Security was the most common concern preventing adoption of cloud-based services. About 20 percent of respondents mentioned security as a major reason that they are wary of the cloud. One expressed concern about what really would happen to his data if his company changed data services provider. Many others cited extremely valuable information and a lack of trust in the security of the cloud as a concern preventing them from making the move. Specific cases included law firms with sensitive court and client documents, and a health organization which was required to be HIPAA-compliant with all data-handling, and wasn't sure how that translated to the cloud. In one counter-example, a firm moved its secure information to the cloud because it was worried about the data being accessed from inside its own, less secure corporate network.

Psychological barriers to cloud use were many and varied

Other barriers that prevented respondents from using the cloud:

- custom software not compatible with cloud software
- no need to access applications outside the office
- not a priority
- too expensive
- "simply haven't gotten to it"
- long-term viability of cloud providers
- Lack of understanding of what the cloud was or how they could take advantage of it.

For very small organizations, the matter of up-front cost was of some concern. For most companies though, the general feedback received in our surveys was that virtualization and the cost savings of energy efficiency in server rooms was simply not a priority. When trying to create incentives that will drive small businesses and organizations toward virtualization, utilities should focus in large part on education and demand creation.

Our survey respondents did not generally find fault with the value proposition of cloud computing and virtualization itself. As organizations become more familiar with the benefits of virtualizing servers, migration to the cloud is likely to increase.

Unaligned Incentives

The most common issue preventing companies from taking advantage of server room energy efficiency best practices was unaligned incentives. For those customers who are either in the cloud, rent servers, co-locate servers, or do not pay their electricity bill, the energy-saving benefits of virtualization often do not accrue to them. This sharply contrasts with large data centers and large corporate server rooms, who usually pay their full utility bill. If small server room customers did adopt virtualization, it was for performance, resilience, and flexibility benefits.

Lack of Information

Some companies and organizations surveyed lacked basic information about virtualizing servers. Some of the smaller organizations were not convinced that virtualizing their small server fleet (fewer than 10 servers) was worth the investment (though research shows it can be), while others had not even heard of virtualization.

Technology is Not the Problem

Only a few companies responded that there were technological issues with virtualizing. One organization had custom chipsets that were not compatible, another thought that virtualization created a lag that was unacceptable. In general though, technology was not a barrier to adoption.

V. POLICY RECOMMENDATIONS

Encourage Use of the Cloud through Education

By migrating operations and applications to the cloud, a company can effectively outsource its server energy consumption. In general, cloud services offer much lower environmental footprints than in-house computing, due to the sharing of resources among many customers (a concept known as "multi-tenancy"), economies of scale, and the fact that cloud data center operators have strong financial incentives to adopt energy efficiency best practices. However, it is important to note that some of the cloud efficiency benefits are offset by increased network consumption, and that there may be large differences in energy footprints between different cloud service providers, depending on the energy mix that produces their electricity. Migrating more operations to an efficient cloud will require communication and education about the logistics, benefits, and security of customer data. Cost is not a substantive issue; most companies agree that moving to the cloud would save them money.

Increase Virtualization Use through Creative Incentive Programs and Policies

NRDC's survey results reveal that there is still significant growth potential for the large-scale adoption of energy efficient practices in the small server room market. Compared to their large data center counterparts, small server rooms are slow to adopt these practices. Small server rooms face challenges and market barriers that are different from larger data centers, including unaligned incentives, lack of information and expertise, and low prioritization.

Our survey results indicate that technology is not the main barrier to adoption of more energy efficient practices. Respondents largely agree that available technologies can provide cost savings, energy savings, and performance improvements. Server room technologies are constantly improving, driven by sales in the larger data center market.

While hardware standards and voluntary programs can improve hardware efficiency, they have not convinced the majority of small server room operators to capture the largest benefits of best-practice operations, such as virtualization, migrating to the cloud, and power management. Other policy options will be necessary to provide stronger incentives and increase the adoption of these operational best practices. Companies' use of virtualization can be expanded through utility programs with robust marketing and outreach, training and education programs for both IT managers of small server rooms and the IT service provider firms that support them.

Overcome Split Incentives to Increase Participation

Split incentives—such as when tenants so not pay for utilities so have little reason to reduce electricity use—can weaken the business case for reducing server electricity consumption. But there are many other reasons that adopting virtualization can be attractive to an organization. Utility or state programs that build incentives such as rebates for the adoption of virtualization, can partner with manufacturers and service providers to communicate these benefits. Utility or state programs can also act as demand aggregators for manufacturers and service providers, who have not attempted to or been effective at penetrating the small server room market.

Take Advantage of Specific Windows of Opportunity

IT managers are busy. The best time to influence server users is during a period when they are investing in new technology. Utility or state programs can provide incentives to IT resellers and service providers that will encourage them to push virtual servers to their customers when they are most willing to buy, and when the capital savings are the most attractive.

VI. CONCLUSION

Small server rooms have not adopted energy efficiency as aggressively as they should, despite significant cost savings to be gained from existing technologies. Virtualization and migration to the cloud are two strategies that could be adopted for small server rooms, and that would have substantial business and environmental benefits, including reducing overall electricity consumption. Although the small server room market is large, it is also diffuse, making it a challenging sector for vendors to penetrate. Small servers encounter multiple barriers to adoption that larger data center and enterprise server markets do not. Many of the barriers are not technological; a lack of awareness and low prioritization are the largest issues barring widespread adoption of these superior technologies.

State and utility programs need to create programs that specifically target this large yet hard-to-reach market segment. As communication efforts pay off and a larger number of small organizations begin to adopt best practices in energy efficient operations, the market will transform and fewer incentives and programs will be needed to help it grow. This phenomenon is already beginning to happen with large data center markets.

ENDNOTES

1   Koomey, Jonathan G. "Growth in Data Center Electricity Use 2005 to 2010." (*Environmental Research Letters*, vol. 3, no. 034008, September, 2011), Page 14, doi:10.1088/1748-9326/3/3/034008

2   The Climate Group, "Smart2020: Enabling the Low Carbon Economy in the Information Age." Global Sustainability Initiative, 2008. www.smart2020.org

3   Server virtualization refers to the consolidation of applications, or virtual servers, onto a single physical server, increasing server utilization while dramatically reducing energy use compared to one server per application.

4   Vanson-Bourne, "V-Index: Virtualization Penetration Rate in the Enterprise." 2011. http://www.v-index.com/full-report.html

5   Our analysis places the cost-effectiveness threshold of virtualization at 5 servers. Using this threshold, 70 percent of our survey respondents would benefit from virtualization on cost-savings basis alone. Even with this projection, 52 percent of respondents that would benefit from virtualization have not tried it.

6   As an interesting nuance, most of the companies who had previously virtualized were certain of their plans to increase their virtualization rate, while the companies who had not yet virtualized more often said they "hoped" to do virtualization in the next year. This suggests an initial barrier of reluctance to adopt a business practice that proves its worth upon adoption.

7   63 percent of respondents use one or more application(s) hosted in the cloud, such as Google Docs, SalesForce, SPAM filters, and Customer Relationship and Human Resource Management software.