

Taking a Byte Out of Data Center Energy Use!

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ABSTRACT

An EPA estimate indicates national energy consumption by servers and data centers could double by 2011 from 1.5 percent of total U.S. electricity consumption to 3.0 percent (EPA 2007). EPA estimates that they can save 20 to 55 percent of the energy use of data centers (EPA 2007) with improved operation measures that include consolidation of and elimination of unused servers, power management, and improved airflow management.

Today, many new products and service providers are emerging to address the growing energy use of data centers and servers. The challenge is to get data center professionals and IT directors to overcome their barriers and adopt the proposed solutions. In addition, there is a need to confirm the direct and quantifiable energy, environmental, and economic benefits, and to identify any potential problems from implementing these various products and measures.

A statewide project has been initiated in New York State to identify and overcome these barriers. The project includes a market scan to identify and categorize the full range of practices and technologies, and programs available to reduce the energy use of data centers and servers. In addition, a market assessment is being conducted to determine the level of energy efficiency measures implemented for key end-user customer segments that would be targeted with prescriptive measures.

This paper describes the approach to the market assessment conducted for the statewide project sponsored by the New York State Energy Research and Development Authority. The results will be used to help design future programs.

Introduction

According to the United States (U.S.) Environmental Protection Agency (EPA)'s August 7, 2007 report to Congress (EPA 2007), national energy consumption by servers and data centers is estimated to have doubled by 2006 compared to 2000. EPA's study also projects that server and data center energy may double again by 2011 from 1.5 percent of total U.S. electricity consumption to 3.0 percent (EPA 2007). At the same time, the EPA report acknowledges that these estimates are approximate because of the limited data on current data center energy use.

To put data center energy use in perspective, one industry expert from EYP Mission Critical Facilities indicated that "a large datacenter today, not a typical, but a relatively large datacenter uses more energy than a city with 25,000 people or so."¹ The Green Grid² estimates that the energy consumption of an individual server with 5 percent utilization is about 1,800 kWh annually. EPA estimates that they can save at least 20 percent of the energy use of data centers with low-cost improved

¹ ENERGY STAR Energy Efficient Servers and Datacenters Podcast, August 27, 2007, Andrew Fanara, U. S. EPA; Peter Gross, EYP Mission Critical Facilities; Dick Sullivan, EMC Corporation; Lorie Wigle, Intel's Digital Enterprise Group; and Christian Belady, Microsoft.

² The Green Grid White Paper #7 "Five Ways to Reduce Data Center Server Power Consumption" Mark Blackburn, 2008

operation measures that include consolidation of and elimination of unused servers, power management, and improved airflow management. More aggressive measures would save up to 55 percent of the energy use of the servers.

It is clear from the literature that there are significant opportunities to reduce data center and server energy consumption. There are a number of manufacturers, equipment vendors, and design consultants who offer a variety of products and services to reduce energy consumption of data centers and servers. Many of these are low-cost IT software and hardware solutions that are relatively easy to adopt including, but not limited to:

- Consolidation of existing servers and elimination of unused servers
- Virtualization of remaining servers
- Procurement of energy efficient servers with improved power supplies when replacing or adding servers
- Power off and power management of servers when not needed
- Storage power management and centralization of servers

There are also a variety equipment replacement and design improvements to achieve energy efficiency in the electrical and cooling systems outside of the IT software and hardware. These options may require more capital investment but could be cost-effective for specific data centers, depending on the current configuration and the expansion plans.

Many equipment manufacturers and software developers are now deeply involved in addressing energy-efficiency in data centers and servers including IBM, Dell, Hewlett Packard, Microsoft, Intel, AMD, Sun Microsystems, and several other Fortune 500 companies. The Climate Savers Smart Computing Board of Directors and members are a “Who’s who” in the computing industry. In addition, there are a growing number of consultants who specialize in the overall design of the server room to optimize cooling and ventilation. The problem is to ensure that the data center professionals understand the opportunities for their facility and have the information that they need to follow through with an energy-efficiency project. In particular, they need good data on the energy consumption in their data centers and server rooms and they need to understand how to optimize their equipment utilization and location design to control their energy use. A recent survey of 100 data center professionals by Aperture Research Institute found that one of every five of those surveyed were not aware of the maximum power density of their server racks.³ Another independent study by Quocirca Ltd. that included surveys of 301 data center decision-makers found that 28 percent did not even know the exact number of servers in their facility.⁴

This paper discusses the market assessment sponsored by NYSERDA to identify the full range of practices and technologies, available to reduce the energy use of data centers and servers. In addition, the assessment will identify vendors and industry experts, appropriate market segments, and the size of that market for prescriptive measures, and the various ways to approach that market in New York State.

Project Background

The New York State Energy Research and Development Authority (NYSERDA) is committed to achieving 840,000 MWh of energy savings in the Industrial and Process sector by 2013. A significant target within that sector includes data centers. In meeting the savings goal, NYSERDA’s Program will offer a “portfolio of services and strategies that provides the greatest impact on energy savings, energy awareness, and energy efficiency penetration into the sector in a cost-effective manner.” In that context,

³ Data Center Professionals Turn to High-Density Computing as Major Boom Continues, Aperture Research Institute, April 2007.

⁴ Data Centre Asset Planning—Regaining Control of the Data Centre, Quocirca Insight Report, March 2008.

the emphasis of the project is on comprehensive projects with large commercial customers that include enterprise data centers.

The market assessment discussed in this paper began with a review of the measures that target data centers and servers but also includes measures that would appeal to smaller customers that are not targeted in the Industrial and Process program. Many customers do not have the resources to conduct comprehensive overhauls of their data center, but can implement a number of measures now and then implement more comprehensive measures in stages to reduce electric usage from their IT equipment. The key is to provide the education, tools and other resources that will help them implement projects in their facility.

The market assessment focuses on a critical need to address these smaller on-site data centers and servers, possibly through a prescriptive program that could include UPS, virtualization software, power management, servers (ENERGY STAR), and other IT solutions. Based on the experience from NYSERDA's Energy SmartSM Offices projects, IT staff, working closely with the facilities manager, are very interested and receptive to ways to reduce the electric bill for their computing equipment. Both the facilities manager and the IT staff want to be educated on what measures can be implemented on their network and convinced that there will be no adverse effects. At the same time, NYSERDA's project managers need to understand the potential savings opportunities and the most effective programs approaches in working with customers and upstream market actors to facilitate those savings. In some cases, education and information are enough. In other cases, incentives may be needed to reduce barriers to adoption of the measures.

Some of the key issues or questions that NYSERDA is examining as part of this project and related other efforts include:

- What are the best approaches for measurement and verification? – NYSERDA is working with a small group of industry professionals to develop protocols. Any protocols or procedures will most likely be done on a customer by customer basis depending on the measure type.
- What measurement and tracking is appropriate for software solutions? – NYSERDA may promote the use of virtualization on servers and storage units, which present a challenge to measure savings. Energy costs often are dwarfed by other aspects of data center economics. Virtualization saves considerable more in labor and hardware costs than in energy, which may lead to high free ridership. Another evaluation issue is how to measure savings when computing productivity increases so energy use per unit decreases, while total energy may increase.
- How would programs address prescriptive measures in addition to comprehensive approaches? – The Industrial and Process Program (NYSERDA's new program to address data centers) will target, and address, large commercial customers seeking comprehensive services. There is still a need to address prescriptive measures.
- What are the best benchmarking and analysis tools? – NYSERDA is looking at a number of tools for benchmarking. DOE Save Energy Now and EPA ENERGY STAR are coordinating efforts to develop tools to assist data center operators in characterizing their energy use and identifying savings opportunities.. The DOE Save Energy Now DC Pro tool suite⁵ and the EPA ENERGY STAR Portfolio Manager tool (which will house EPA's energy performance rating for data center infrastructure) will be linked to facilitate the transfer of data for users.⁶
- What is needed to build the market in New York State for energy efficient IT products (efficient servers, etc.)? – NYSERDA will need to identify and engage the manufacturers and suppliers of efficient IT products that would be available to customers in the state.

⁵ http://www1.eere.energy.gov/industry/saveenergynow/printable_versions/dc_pro.html

⁶ http://www.energystar.gov/ia/partners/prod_development/downloads/NDCFactSheet.pdf

This market assessment project addresses program design issues by characterizing the market, identifying key barriers, and recommending solutions to reach and inform target groups. Other projects initiated by NYSERDA are addressing measurement and verification.

Barriers and Possible Solutions

In discussing our solution, it is important to discuss the barriers to adopting energy-efficient data center and server measures. Based on the NYSERDA Energy \$mart Offices experience and the EPA findings, the following table lists key barriers and proposed strategies to be implemented in developing the market for energy-efficient data centers and servers.

Table 1. Barriers and Strategies to Developing a Market for Energy-Efficient Data Centers

Key Barrier	Strategies to Address this Barrier
Lack of Information and Monitoring on the Current Energy Use With No Clear Definitions and Benchmarks for Energy Efficiency	Summarize methodologies, tools, and data so that IT and data center professionals can estimate the energy use and savings opportunities for their data center. There are some simple metrics that include Power Usage Effectiveness (PUE), which is the Total Facility Power divided by the IT Equipment Power, or its reciprocal defined as Datacenter Efficiency (DCE). The Green Grid also supports the use of Datacenter Performance Efficiency (DCPE) that considers the Useful Work as a proportion of the Total Facility Power. The key is to be able to measure those variables. There are also simple calculations of individual server kW and kWh based on power output and utilization. Further, NYSERDA’s demonstration projects should yield actual examples of energy costs and savings. Some average data and simple calculators can be developed for NYSERDA’s web site along with links to EPA’s project to estimate data center energy use. In addition, the results of the demonstration projects will be summarized in a central location and as part of a regional workshop while working with the demonstrations.
First Cost	Review and summarize the list of energy efficiency opportunities with the measure costs compared to the costs expanding or relocating overloaded data centers. Identify first-step low-cost measures that can be done easily without significant capital investment. Prepare checklist to identify measures that could apply to a data center based on current situation, savings opportunities, and cost to implement.
Split Incentives/ No Incentive for IT to Implement EE Measures	Conduct interviews of IT managers who direct their own data centers in-house to identify those who have and those who have not taken actions to implement energy efficiency measures. Identify incentives and disincentives for those IT managers including non-energy benefits to their data centers. Explore innovative options that may include assigning responsibility for the energy bill for their equipment and server rooms to the IT managers. Prepare case studies for NYSERDA web site, webinars, and regional workshops that address this barrier.
Risk of Outages/ Loss of Redundancy	Review existing research and demonstration project results, and conduct interviews of IT managers and vendors to determine the level of concern about this issue. Identify example projects that have successfully overcome this barrier and present the results. Develop materials with testimonials for NYSERDA web site and regional workshops. Track and report on demonstration results and incorporate into outreach materials and activities.
Information on Vendor Products and Services	Conduct a review of vendor products and services and summarize the findings to support the decision-making process. The project team does not sell products or design services that would be used by the data center professionals and IT staff. This puts us in a position to be an objective source of information for NYSERDA and the potential end-users. The Energy \$mart Offices team is already considered a trusted and knowledgeable source of energy-efficiency information related to computers, servers, and other equipment managed by the IT departments of offices, governments, school districts, and colleges in New York State.

The project team’s experience in working with IT directors at about 60 Energy \$mart Offices projects over the past 6 years indicates that system reliability is their number one concern. Most IT directors are slow to adopt measures that are primarily geared to saving energy. At the same time, they do network with other IT directors in their sector including government, municipal school districts, colleges, and other targets for this project. They are more likely to adopt measures if other similar

facilities in New York State have done so and are used as case studies to show there have been no negative impacts.

The Energy Smart Offices team also found that IT directors and even facility managers are not very knowledgeable about the energy use of their computing equipment and what the potential savings could be from low-cost energy-efficiency measures. For that reason, the Energy Smart Office program conducted on-site equipment surveys and other data collection to estimate energy use and saving opportunities.

The EPA Report to Congress (EPA 2007) pointed out similar barriers that need to be overcome to ensure more data centers adopt energy-efficiency measures that are cost-effective.

Methodology

Our approach to this project includes four major activities:

- Review the current situation—develop a matrix of solutions and vendors; summary of program best practices; and list of resources to facilitate energy-efficient data centers and servers.
- Conduct a market assessment—summarize the survey results including key barriers and ways to overcome to barriers to achieve energy-efficient data centers and servers.
- Design and implement a regional workshop—beginning with a sector base conference, most likely Colleges and Universities
- Develop outreach materials and a web-presence for information on efficiency opportunities

Review of Current Situation

The review of the current situation includes energy-efficient equipment and practices, current industry programs, and existing research and demonstrations.

Energy-efficient products and services for data centers and servers. The project team's is developing a list of measures, hardware and software solutions, design approaches, and other options that are available to reduce energy consumption of data centers and servers. These range from low-cost measures such as power management and powering off of servers to more expensive redesign of the server rooms to optimize cooling loads. The deliverable is a summary of these energy savings opportunities with relative costs, range of savings, pros and cons, and vendors.

Current industry programs. The team is investigating the types of programs currently available to consumers, nation-wide and within the New York market to overcome barriers to measure adoption. These programs, often customized for each organization, range from server consolidation projects to installation of cooling technology and efficient servers. The market assessment focuses on both 'standard' industry offerings, as well as programs that support more innovative offerings. The intent is to identify best practices for promoting energy-efficient data centers and servers. According to one publication, there are currently over 80 energy efficiency programs supporting IT consolidation and data center improvement projects⁷. Examples of utilities offering these types of programs include: Pacific Gas and Electric, San Diego Gas & Electric; Xcel Energy, Austin Energy, Avista Utilities, Con Edison, and Efficiency Vermont.

Existing research, demonstrations, energy analysis tools, and other resources. A thorough Internet search is being conducted, along with a review of other industry sources such as the Division of Energy (DOA), Oak Ridge National Laboratory (ORNL), and Lawrence Berkeley National Laboratory (LBNL), Climate Savers Computing Initiative, The Green Grid, ASHRAE, and Environmental Protection Agency (EPA) ENERGY STAR. In addition, the literature review will include professional

⁷ <http://www.datacenterknowledge.com>

organizations web sites and their conference proceedings such as Datacenter Dynamics and Datacenter Knowledge.

Market Assessment

One cannot understand how best to market new measures and tools without fully understanding the end-users of the technology. While data requirements continue to grow exponentially, end-users are reacting through their purchasing and retrofitting practices. Additionally, investigating decision-making processes and trade-off analysis is important to understanding end-users' reception to these technologies. In particular, the market assessment identifies the key barriers to adoption of energy-efficient data centers and servers and discusses ways to best overcome those barriers.

To assess the market, structured interviews are being conducted with 75-100 organizations that operate data centers and servers in New York State. The list of customers are provided from the five ASHRAE training sessions on energy efficient data centers that have been implemented by NYSERDA throughout New York State. Attendees represent a variety of organization-types. The surveys are designed to yield quantitative data, but while allowing for qualitative information to be gathered as well. The survey includes: a characterization of the data center (e.g., number, types, rack power consumption, and ages of servers, percent utilization); past and planned expansion and relocation; energy-efficiency actions taken and planned and awareness; barriers to taking actions; ways to overcome those barriers; and decision-making processes. In addition, the survey would help identify sources of information on the topic of energy-efficient data centers and servers including activities and workshops currently being conducted in New York State.

The sample should help identify target industries that would benefit most from prescriptive measures and more education. The sample may include interviews with property managers and IT directors for commercial office buildings and data centers. Many research buildings, office complexes, office buildings, and other types of facilities have small to medium or even large data centers. When the building is owned by the tenant, contacting the IT director may simply be a matter of contacting the company or working through utility account representatives to contact the facility engineer or manager who can make the contact.

Regional Workshop

The project teamed with SUNY Albany, who is working with NYSERDA on an energy efficient data center project, to develop a regional workshop that will include case studies and information on valuable tools and resources available from NYSERDA and other sources. This initial workshop will be held in conjunction to a planned ASHRAE training session and focuses on the colleges and universities sector—public and private—within New York State. The objective is to help this segment with practical experience and resources to influence them to implement energy efficient data center projects and measures by providing information pertinent to operating a campus data center. SUNY Albany's manager of data center operations will present their experience in identifying and implementing energy efficient data center measures. Other topics include the results of the current situation analysis and market assessment starting with examples of energy and non-energy benefits of energy-efficient data centers and servers based on several project case studies and demonstrations. The workshop will also present the strategies, products and services, analytic tools, educational materials, and other resources available to data centers and servers.

Outreach Materials and Follow-up

The deliverables of the project including the PowerPoint presentations from the workshops will be posted on the NYSERDA web site. Additional information planned for the web site include technical briefs, case studies, data, analytical tools, and links to other key web-sites and resources. A follow-up survey is planned for the regional workshop attendees to evaluate the workshop and identify actions that have been taken or planned to reduce data center and server consumption. The survey will also include others who have used the project resources to assess the value of the education and information components.

Summary and Next Steps

There exists a major opportunity to reduce the major growing load for data centers and servers in New York State. The market is exploding with conferences, training sessions, consultants, and new products and tools to analyze and optimize data center configuration and server use. Much of the emphasis is still on larger data centers, including enterprise data centers, with comprehensive projects that achieve significant energy savings. At the same time, these programs and services need to recognize the huge potential for smaller projects at on-site data centers and server rooms. Many of these customers do not have the resources and information to implement energy efficient projects and are more likely to look for prescriptive measures that can be implemented in stages. These customers also differ from enterprise data centers in terms of their internal barriers and needs to serve internal clients. These barriers are best addressed by providing presentations and case studies from their peers in the same industry who have implemented projects in similar facilities. In addition to case studies and access to demonstrations, the customers who are candidates for prescriptive measure programs, need education and information on various options for their type of facility.

NYSERDA has implemented this market assessment project to address those needs. The results for the initial tasks will be presented at the 2009 International Energy Program Evaluation Conference in August. These include the results of the market scan, or situation analysis, and the market assessment including the results of the surveys of targeted customers.

As the market assessment leads to effective programs designs, the additional challenge will be to develop evaluation, measurement, and verification procedures that will efficiently and accurately measure the program savings.

References

U. S. Environmental Protection Agency (EPA): ENERGY STAR Program. *Report to Congress on Server and Data Center Energy Efficiency*. August 2, 2007.