Improving Data Center Efficiency: Some Policy Possibilities

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Barriers & Hurdles

Although energy saving opportunities in data centers are widespread and can reap significant cost savings, implementation costs and other barriers often impede their adoption.

Despite the rising cost of electricity and the relatively large share of data center costs represented by energy expenses, data center energy costs remain a relatively small portion of overall costs for most data center clients, especially those with small and medium sized data centers.[1] Compounding the problem is that most data center managers never see the energy bill for their facilities, and their performance is not based on energy costs.[2] While the company or institution using the data center may benefit overall from the adoption of energy efficiency improvements, the data center will probably see little reward. Separately metering data center operations would facilitate accountability and possibly provide an economic incentive directly to data center operators for improved energy performance.

While the job performance and salaries of most data center operators will likely never be based on the center's energy costs, disruption of operations resulting from attempts to institute new and untested software, hardware, or cooling innovations to improve data center energy efficiency could very well threaten their jobs. For example, a leak in a liquid cooling system could be disastrous. Some software manufacturers advise operators not to run on virtual servers because they have not tested the virtualization software with their software and do not want to be held liable for any resulting instability.[3] It is not surprising that data center operators might not immediately adopt every new technology or idea. Successful adoption of new technologies and processes, especially by peers, may provide the most compelling information for a data center operator.

Data center operators need confidence in manufacturers' claims that operations will not be disrupted by the installation of energy efficient improvement. They also need sufficient knowledge to convince budget decision makers that the measures are worth financing. The rapid growth of data centers and the disconnects that exist between architects, financial managers, and data center operators often lead to poor data center design and operation. The challenge is in weighing the energy efficiency and other benefits that the improvements will yield against the potential risks that they may bring to data center operations, and then communicating those benefits and risks to financial

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[1] Kevin J. Delaney and Rebecca Smith, "Surge in Internet Use, Energy Costs Has Big Tech Firms Seeking Power," *Wall Street Journal*, June 13, 2006, p. A1. According to Yahoo's CFO, while electricity represents 20-50% of running a data center, power is a minor part of Yahoo's overall costs.

[2] Darrell Dunn, "Power Surge," *Information Week*, February 27, 2006.

[3] Abir Trivedi, Alliance to Save Energy, personal Communication, August 17, 2006.

decision makers. Indeed, making the financial case for purchase of an efficiency improvement may be a greater hurdle for data center operators than actual implementation of the efficiency measures. Facilitating conversations between these groups of people and providing guidance that can be used in those communications is a critical need.

Perhaps the greatest barrier to energy efficiency improvements has been the rapid increase in new computer applications combined with the rapidly falling cost of processing power. If procurement criteria do not specify the purchase of energy efficient equipment, that factor is likely to be lost in purchasing decisions. It is difficult to continually optimize data centers in such a rapidly changing environment and even more difficult to predict future requirements.[4] Because HVAC systems have long-lived components, while IT equipment has a relatively short life, HVAC systems often end up being mismatched with IT equipment and its cooling requirements.[5] Consequently, data center operators tend to err on the side of too much capacity rather than too little, resulting in less efficient operation.

As discussed above, outsourcing of data center operations can help concentrate expertise and consolidate applications to allow more efficient use of servers and other equipment. However, pricing for these services is sometimes based on the number of servers that are used. Consequently, sellers of data center services may have little incentive to encourage efficient use of those servers through consolidation and virtualization of applications and other efficiency improvements. Outsourcing will produce no energy efficiency improvement unless it results in a higher utilization rate for the servers being used or unless the data center service provider has made investments in efficiency that take advantage of economies of scale.

Existing Programs and Policies

To date, there has been little public sector role in promoting and facilitating improved data center energy efficiency by overcoming the barriers discussed above. As data centers comprise a growing portion of electricity use, governments and electric utilities are increasingly recognizing the need to take actions to reduce data center energy consumption. Because of the societal benefits achieved by data centers, it is important that these actions do not discourage innovation or impede server performance. Data center energy performance can be enhanced through any number of measures, including the issuance of energy performance metrics, design and operation guidance, government procurement requirements, and financial incentives.

Energy Performance Metrics

[4] Roger Schmidt and Don Beaty, "ASHRAE Committee Formed to Establish Thermal Guidelines for Datacom Facilities," *Electronics Cooling*, February 2005.
[5] Schmidt and Beaty.

Defining "energy performance" is a prerequisite for most energy efficiency policies and programs, and programs targeting data centers are no different. The way that performance is measured is critical, as it can determine if a server or other equipment will meet a consumer's needs or be eligible for utility rebates or required as part of federal or state procurement requirements.

Developing performance metrics for even the simplest types of equipment can prove difficult and controversial.[6] For example, it has taken several years to develop widely accepted testing methods and energy efficiency standards for power supplies. The 80plus® performance specification, whose development was funded by electric utilities, requires computer and server power supplies to operate at 80-percent efficiency at 20, 50, and 100 percent of rated capacity.[7] More than 20 power supply manufacturers have submitted products for 80plus® certification and some computer manufacturers are now selling computers with certified power supplies.[8] Due in part to the efforts of the 80plus® program, the ENERGY STAR program is considering developing ENERGY STAR labels for power supplies in the future.[9]

EPA has also been working with industry and other stakeholders to develop measurement protocols for servers and, in November 2006, EPA distributed a final server energy efficiency measurement protocol drafted by Lawrence Berkeley Laboratory with other stakeholders.[10] Note that power supply performance is relatively straightforward—i.e., unit of energy output per unit of energy input – compared to measuring server energy performance. Applications processing is the desired output of a server, which is more difficult to measure than energy output.[11] At least one challenge is in the range of

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[6] PowerPulse.net, "EPA and DOE's Energy Star Seek Comments on Proposed Energy Management Protocol," *PowerPulse.net*, August 22, 2006. Retrieved August 24, 2006 from http://www.powerpulse.net/story.php?storyID=15822. Also, Greg Papadopoulos, "Impacts and Importance of Energy Efficiency, Industry Viewpoint", Conference on Enterprise Servers and Data Centers, January 2006 at www.energystar.gov/serverconference; Christopher Malone and Christian Belady, "Metrics to Characterize Data Center & IT Equipment Energy Use, *Proceedings from 2006 Digital Power Forum*, September 2006; Magnus Herrlin, "Prerequisites for Successful Energy and Thermal Management in Data Centers: Metrics," *Proceedings of 2006 Digital Power Forum*, September 2006.

[7] As with power supplies, servers are often operated at far less than their rated capacity. As noted earlier, manufacturers' ratings have traditionally been based on operation at maximum capacity, which can be misleading because power supplies, like servers and other data center equipment, often operate at partial loads.

[8] See 80-Plus web site at http://www.80plus.org/cons/cons.htm.

[9] Andrew Fanara, Environmental Protection Agency, personal correspondence. Note that ENERGY STAR labels exist for external power supplies, just not internal power supplies, which are sold as OEM equipment in computers and servers.

[10] The protocol is available form EPA's web site at www.energystar.gov/datacenters and was written by LBL in collaboration with representatives from AMD, Dell, Hewlett Packard, IBM, Intel, Sun Microsystems, Stanford University, Rumsey Engineers, the California Data Center Design Group, and the Uptime Institute.

[11] If measured on the same basis as power supplies, servers would have almost zero-efficiencies because almost all of the energy that goes into the server is exhausted in the form of waste heat. Although this waste heat is undesirable, it does not mean that the server has failed at successfully running a database or web browsers.

applications; Different computers (and chips) are optimal for different applications. This makes simple across-the-board comparisons difficult.

The server protocol presents a method for adding energy measurements to existing performance metrics (e.g., web pages served per minute). The result is a measure that will demonstrate the wattage consumed by a server at different loads. This will allow consumers to compare the energy consumption of different manufacturers' servers based on performance metrics that consumers and manufacturers are already familiar with and are using.

The protocol avoids, at least for now, debates about which performance metrics are better. Meanwhile, the Standard Performance Evaluation Corporation (SPEC), a non-profit organization that develops benchmarks for computers, expects to complete its first energy performance protocol—for small to medium-sized servers—in the beginning of 2007. SPEC will use its current application benchmarks as the basis for generating loads that are "typical of day-to-day server use." [12]

The importance of these efforts cannot be overstated. Standard measures of performance will increase the ability of data operators to compare products based on energy performance, making them more likely to consider energy performance in their purchasing decisions. An energy performance measurement standard, based on established and familiar server performance measures, will help increase users' confidence that the overall performance of the energy-efficient server will not be lower than the standard server. Last, but not least, widely accepted energy performance metrics and criteria for servers – and for entire datacenters - will provide the groundwork for other policies that will promote the development and purchase of energy efficient servers – including, for example, government procurement policies and financial incentives, such as tax rebates and credits.

Design and Operation Guidance

The growth of data centers is a relatively recent phenomenon, thus design and operational best practices have only recently been developed. Lawrence Berkeley National Laboratory (LBL) has been a pioneer in the field, providing technical resources to help designers and operators improve data center energy performance. The LBL website contains a wealth of information, including benchmarking tools, case studies, and technical reports covering everything from power supply efficiency measurements to surveys of data center operations.[13] To date, LBL has focused on power supplies, distribution and cooling and offers few resources pertaining to applications management and servers.

[12] Standard Performance Evaluation Corporation, "SPEC to develop energy metrics for servers: New committee explores intersection of power use & performance," May 18, 2006. http://www.spec.org/specpower/pressrelease.html

[13] LBL's data center energy efficiency web site is at http://hightech.lbl.gov.

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) develops standards for buildings and building systems, versions of which have been incorporated into most state and/or municipal governments' commercial codes. ASHRAE Technical Committee 9.9 Mission Critical Facilities, Technology Spaces, and Electronic Equipment was established to "provide better communications between electronic/computer equipment manufacturers and facility operations personnel to ensure proper and fault tolerant operation of equipment within data processing and communications facilities."[14]

ASHRAE Technical Committee 9.9 has developed guidance to address at least three aspects of data center design and operations that were discussed above:

1) Thermal Guidelines for Data Processing Environments—provide temperature and humidity guidance for data centers (as well as for other types of computer environments). [15]
2) Air flow protocols for servers—provide a common airflow scheme so exhaust from one manufacturer's equipment is not being ingested by another manufacturer's air inlet— e.g., the front face of all equipment should face the "cold" aisle.[16]
3) Power Trend Charts—Address the mismatch of HVAC and IT equipment due to different lifetimes and help data center operators/designers predict future IT requirements. [17]

Other organizations that provide resources for data center operators and designers that may be useful in improving data center energy efficiency are summarized below.[18]

- *GreenGrid*: An association of information technology professionals seeking to lower the overall energy consumption of data centers globally. The GreenGrid allows members to share best practices in data center power management. (http://www.thegreengrid.org)
- *Efficient Power Supplies*: A website created by EPRI Solutions Inc. and Ecos Consulting to encourage a global discussion of energy-efficient power supplies. (http://www.efficientpowersupplies.org)
- *ITherm*: "An International conference for scientific and engineering exploration of thermal, thermomechanical, and emerging technology issues associated with electronic devices, packages, and systems." (http://www.itherm.org)
- *Consortium for Energy Efficient Thermal Management*: A collaboration of Georgia Institute of Technology and the University of Maryland to conduct "research on

[14] Roger Schmidt and Don Beaty, "ASHRAE Committee Formed to Establish Thermal Guidelines for Datacom Facilities," *Electronics Cooling*, February 2005.
[15] ASHRAE, 2004, Special Publication, "Thermal Guidelines for Data Processing Environments." American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. Atlanta , Georgia.
[16] ASHRAE 2004, Special Publication, "Thermal Guidelines for Data Processing Environments." American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. Atlanta , Georgia .
[17] ASHRAE, 2005, Special Publication, "Datacom Equipment Power Trends and Cooling Applications," American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Ga..
[18] A number of additional organizations exist in universities or as part of labs associated with industry companies – e.g., IBM's research lab in Austin, Texas.

thermal and energy management of electronics and telecommunications infrastructure." (http://www.me.gatech.edu/CEETHERM/)

- *7x24*: An association facilitating the exchange of information for "those who design, build, use, and maintain mission-critical enterprise information infrastructures…7x24 Exchange's goal is to improve the end-to-end reliability by promoting dialogue among these groups." (http://www.7x24exchange.org/index.html)
- *Uptime Institute*: Facilities exchange of information for improving reliability in data centers and information technology organizations. The *Institute* sponsors meetings, tours, benchmarking, best practices, research, seminars, and training. (http://www.uptimeinstitute.org/)
- *AFCOM*: AFCOM started as an association of "a handful of data center managers looking for support and professional education." AFCOM membership now includes "more than 3,000 data centers" worldwide. AFCOM provides information to data center managers through annual conferences, published magazines, research and hotline services, industry alliances, and more. (http://www.afcom.com/)

Clearly, a wealth of resources is available to data center operators trying to improve the energy efficiency of their operations. The challenge is to let data center operators know these resources are available and motivate them to take advantage of these resources.

Government Procurement

Federal, state and local governments spend tens of billions of dollars annually on energy-consuming products, thus offering thousands of opportunities to reduce government energy use through the purchase of energy efficient products. Furthermore, government procurement programs are used to help raise awareness of new-to-market energy efficient products, increase comfort levels with their use, and reduce costs of manufacture through economies of scale.

The federal government is required by law to purchase energy efficient products unless they are proven to not be cost effective. To help federal employees comply with these requirements, the Federal Energy Management Program at the U.S. Department of Energy (DOE-FEMP) along with the U.S. Environmental Protection Agency's ENERGY STAR (EPA Energy Star) program have developed energy performance specifications for approximately 70 types of products, including lighting equipment, heating and air conditioning, office equipment and more.[19] Typically, as a starting point, eligible products are in the top-25 percent of their product class based on energy efficient performance..

An 80plus® type specification could be added to the federal product specifications to award the use of the most efficient server power supplies. In fact, some large institutional consumers are reportedly already specifying 80plus® requirements in their procurement policies. The 80plus® program web site provides downloadable procurement specifications to make it easy.[20]

[19] http://www1.eere.energy.gov/femp/pdfs/eep_productfactsheet.pdf
[20] http://www.80plus.org/cons/cons.htm

Once energy performance measurements are developed for servers, DOE-FEMP or EPA Energy Star could develop procurement requirements for them as well. Once minimum energy performance requirements are established for servers, federal agencies would be required to purchase only servers meeting those requirements (unless they provide written justification for not doing so).

Energy performance measurements could also facilitate financing of data center efficiency improvements through energy services performance contracts (ESPCs) and utility energy service contracts (UESCs). Under ESPCs, private sector energy service companies finance, install and maintain new energy efficient equipment in federal facilities at no up-front cost to the government. The energy service company is paid back over time from the dollars saved by the agency on its energy and maintenance bills

Finally, establishing ENERGY STAR or DOE-FEMP eligibility requirements for servers could increase purchases of energy efficient servers by local, state and foreign governments, some of whom use ENERGY STAR and DOE-FEMP eligibility requirements in their own procurement practices.

Financial Incentives

Financial incentives can help buy down the additional cost of more energy efficient data center equipment, compensate for the increased "hassle factor" that may be associated with their installation and use, draw attention to innovative technologies, and legitimize the technologies in the eyes of the purchaser, who will sees that government and/or electric utilities are essentially endorsing these technologies. An important element of the 80plus® program is that participating utilities agree to provide a $10 rebate to manufacturers of servers that install power supplies that are certified to be at least 80 percent efficient. [21] These types of rebates are similar to rebates that have been offered by governments and utilities over the last couple of decades to a wide range of energy efficient products.

Financial incentives may also be catching on for servers. In August of 2006, Pacific Gas and Electric Company (PG&E) began offering $700 to $1,000 rebates for efficient servers (up to about 25 percent of the cost of servers). This is reportedly the first utility rebate program ever offered for servers.[22]

The current challenge with this type of program is the lack of standardized server metrics. Once widely accepted energy performance measures are in place, such as those proposed

[21] Utility-related participants listed on 80plus®Program web site are Efficiency Vermont, Midwest Energy Efficiency Alliance, National Grid, New York State Energy Research and Development Authority, Northwest Energy Efficiency Alliance, NSTAR, Pacific Gas & Electric, Sacramento Municipal Utility District, Southern California Edison, Western Massachusetts Electric, and XCel Energy. http://www.80plus.org/util/util.htm.

[22] Sun Microsystems, Inc, press release, August 15, 2006, http://www.sun.com/smi/Press/sunflash/2006-08/sunflash.20060815.2.xml.

by EPA and LBL (as discussed above), these kinds of programs could be offered more widely by utilities, as well as state and local, and foreign governments.[23]

Policy Possibilities

To date, the role of governments in data center efficiency has been limited. The environmental and other social benefits associated with the reduction of electricity consumption and demand warrants an expanded government role, specifically in the following areas:

Metering data center energy use – Governments should encourage sub-metering of data centers to help isolate energy efficiency opportunities among various loads and over time.

Energy performance measurement – Government should support efforts to develop server and power supply energy performance metrics.

Energy performance standards – Governments should consider minimum energy performance standards for power supplies at the 80-Plus level or better. Once performance measures have been established for server, governments should consider adoption of minimum energy performance standards.

Building codes – Governments should ensure that data center best practices are included in commercial building codes. The federal government should work with ASHRAE to ensure inclusion of data center systems that ensure a minimum of energy waste in commercial building standards including an analysis of the sizing of the cooling systems for server areas.

Financial incentives – Where energy performance measures are obtainable, systems are comparable, and budgets are available, governments should establish tax and/or utility incentives for servers, power supplies and other data center equipment and best practices, such as virtualization and consolidation of applications.

Research – Governments should support research in at least the following three areas: 1) server and data center energy performance measures; 2) potential savings and costs from more efficient coding; and 3) potential savings and costs from better applications management

Pilot/Government Program Implementation – The federal government should establish a program and/or pilot projects that mimic real-word data center challenges. In this way, the government can test new energy-saving technologies and ensure compatibility with server software, minimizing the risk to server managers and making energy saving equipment more attractive.

[23] Matt Stansberry, "PG&E to offer energy rebates for Sun servers," *Data Center News*, August 15, 2006, http://searchdatacenter.techtarget.com/originalContent/0,289142,sid80_gc1210722,00.html

Awareness – Governments should work with industry and others to raise awareness of existing information resources about data centers and promote awareness that significant opportunities exist. Government should establish best practices guidelines for distribution and assistance to companies and data center managers.