Innovative technologies: managing IT devices to reduce impacts to building infrastructure

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Abstract

One of the fastest growing energy loads in a typical commercial building is also one of the most overlooked: IT devices such as computers, printers and servers. Regardless of the efficiency – or inefficiency – of any given building, IT devices have a profound impact on energy consumption and electrical infrastructure.

The market has seen an unprecedented proliferation of IT devices in recent years, which despite being more efficient are also more consumptive than at any point in history. More IT devices consuming more energy are a recipe for energy disaster in many commercial building settings.

IT devices, in addition to being voracious consumers of energy themselves, also force HVAC systems to work overtime to account for their additional heat load. In buildings with hundreds or thousands of computers and other IT devices, this cross-effect energy impact can be striking.

Further, existing commercial buildings are increasingly faced with costly retrofits to their electrical infrastructures to accommodate new load for IT devices. The story is the same for new buildings, which are forced to invest more than ever to insure that energy capacity will be adequate for IT demand.

Fortunately, new IT management systems offer ways to dramatically reduce wasted energy in these devices, and deliver 'best in class' opportunities for benchmarking, performance monitoring and ongoing diagnostics. The empirical data that can be collected from IT devices is incredibly granular and accurate, and commercial building owners can now make educated management decisions to navigate this tsunami of new energy load.

Introduction

Which of these industries are responsible for more CO_2 emissions – the global aviation industry or the information technology (IT) industry? According to estimates from Gartner, a group of IT industry analysts, the answer is surprising… They are about the same (Murray, 2007). This type of realization is throwing fuel on the already hotly burning topic of how to curb the insatiable energy hunger of IT devices, as well as their impacts to the buildings in which they reside.

For many years, consumers have benefited from IT products with low price points and high levels of computing performance as manufacturers engaged in what amounted to price warfare. Because energy and environmental improvements often meant adding cost to the system, they were often overlooked in the engineering of IT products. Simply put, anything that added cost was incompatible with a market that prioritized price above all else. As a result, consumers have been incurring a silent but ever increasing energy and environmental burden as their IT infrastructures have grown.

Now, for the first time, a market climate is evolving between manufacturers, consumers and regulators that is motivating great change in the industry and is bringing sharp focus to energy consumption and energy efficiency of IT devices. The convergence of high energy rates, consumer awareness, changing standards by organizations such as Energy Star (US EPA, 2007), and the presence of innovative market transformation programs has created rapidly growing consumer demand for 'green' IT products, and manufacturers are moving quickly to fill this market need.

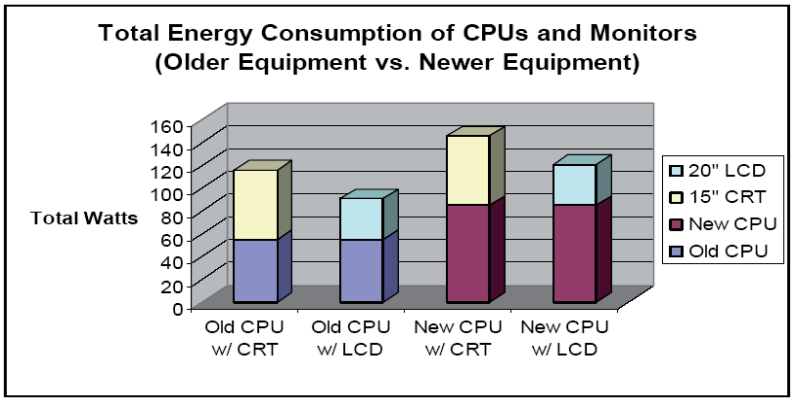

Figure 1. Energy consumption of older vs. newer computers

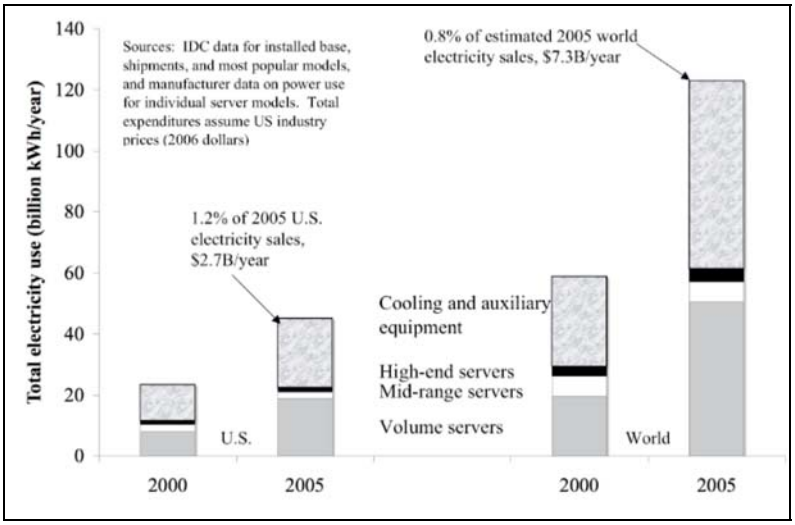

Figure 2. Total electricity use for servers in the U.S. and the world in 2000 & 2005 (Koomey, 2007)

The Myth of Computer Energy Efficiency

The reasons for the rapid growth in computer energy consumption over the past decade are both intuitive and surprisingly counterintuitive. The intuitive reason is simply related to the rapid proliferation of IT devices in commercial and institutional settings. In the case of personal computers (PCs), it is typical in most organizations for there to be at least a one to one ratio of workers to PCs, and many institutions now have more PCs than employees. The counterintuitive reason is that new machines, despite conventional wisdom, are NOT necessarily less energy intensive than their predecessors. Instead, the reality is that despite improvements in the efficiency of power supplies, processors and chipsets, many models of PCs are consuming as much or more energy than ever before.

The rise in IT energy consumption is even more dramatic when looking at the electricity used by servers and other IT devices. A study by Lawrence Berkeley National Labs showed that aggregate electricity use by servers doubled in the U.S. and the world in the five years between 2000 and 2005, and current analysis predicts a similar doubling between 2005-2010.

The equation is troubling: more IT devices consuming more energy add up to unprecedented energy consumption and cost – and most consumers that operate large computer networks, while noting that their energy costs are rising dramatically, are still unaware that the rather silent but pervasive expansion of IT equipment could be at the heart of the problem. The impacts to owners and managers of commercial and institutional buildings are profound. Not only are they faced with the enormous expense of powering IT equipment, but their building infrastructures are often quite simply unable to accommodate this innocuous and unexpected new source of energy load.

Impacts to Existing Buildings

Consider this scenario. You are the facilities/energy manager for a large school district that operates and maintains scores of buildings. During the late 1990s and early 2000s, you had the foresight to invest in a variety of energy efficient upgrades, ranging from lights to windows to HVAC and a variety of other sound measures. However, in the years following those upgrades you are puzzled to find that the savings that you anticipated are in decline, and in some cases by alarming rates. Further, you are facing constant and costly infrastructure improvements to upgrade power and distribution capacity within your buildings. Why is this happening?

Needham Public Schools in Needham, Massachusetts recently engaged in an "Electrical and Technology Infrastructure

Upgrade" that is increasingly common and sheds some light on the scenario above. According to a memorandum issued by the Office of the Superintendent (Needham PS, 2007), an electrical improvement project implemented between 1992-1994 focused on providing adequate electrical service to the buildings, but did nothing to improve the distribution of power within the building to the classrooms, labs and other locations where IT equipment is now a pervasive fixture. In the years following this upgrade, the IT boom hit Needham just as it has virtually every other organization of its kind. Years later, the district is now faced with the costly and disruptive prospect of an additional infrastructure upgrade to expand the number of outlets in each classroom and laboratory, to improve power quality and to take steps to insure the protection of costly – and often mission critical – IT devices. This is an increasingly common situation, and illustrates that the proliferation of IT equipment in our businesses and institutions has occurred so swiftly and quietly that we have been unable (or perhaps unwilling) to plan for their inevitable impacts to our building infrastructures. In the case of Needham, it appears that the lesson has been learned, as the current upgrade project states that "the infrastructure… must be upgraded to support not only the current technology needs of 1200 students, teachers, and administrators, but also to support their needs *well into the next decade*. (Needham PS, 2007)"

A similar, but slightly nuanced, example can be found at the US National Center for Atmospheric Research (NCAR), which in late 2005 completed a massive 8-year upgrade of the computer room at NCAR's Mesa Laboratory (Lester, 2005). NCAR's computer facility had been designed 40 years earlier for machines that needed minimal power and cooling by today's standards. In order to support the latest generation of supercomputers, the facility had to be completely overhauled not only to insure adequate power, distribution and cooling, but to improve power quality and reliability to protect the incredibly expensive and sensitive computing equipment. According to Aaron Andersen, Manager of SCD's Enterprise Services Section (ESS), it was the first upgrade of its size since 1986, and was driven by the NCAR research community's voracious appetite for high-end computing.

LACK OF COMMUNICATION CAN LEAD TO UNINTENDED CONSEQUENCES

Historically, the worlds of IT and Facilities Management have been so separate that interaction between the two rarely, if ever, occurred. Both were considered to be 'services' to the larger organization, and their charters so radically different that there were few circumstances that demanded interaction. In more recent times, the business landscape has changed. IT has become much more than just a service to the larger organization, and is in most cases a mission critical component of any commercial or institutional entity. And while IT equipment has become more pervasive it has encroached on building infrastructure and into the world of facilities management. The inevitable collision of these previously disparate business entities has occurred, and is now hopelessly intertwined. Communication between these groups is essential, and lack thereof can have serious, even damaging consequences.

While a bit dated, a high profile example occurred at the Richland Operations Office of the US Department of Energy in 1999, where "electrical maintenance activities have incapacitated or damaged sections of the site computer infrastructure on several occasions" (US DOE Richland, 1999). In May 1999, scheduled maintenance of electrical infrastructure was executed on site without an impact analysis or communication with IT officials. This maintenance resulted in a number of IT failures, which were both costly to repair and presented an array of potential safety hazards. Upon discovery of these impacts, DOE realized that facilities personnel did not have proper documentation of site computing infrastructure, which changes to the power grid may affect vital computer systems that are unknown to facility owners and that work procedures did not require adequate analysis of the impact of electrical outages on computer infrastructure. In other words, work done on electrical infrastructure was done completely without regard for potential impacts to IT equipment.

Similarly, it is commonplace for IT to make IT purchases without regard for impacts to electrical infrastructure, a scenario that poses an equally challenging set of problems. At the core of each of these situations is the historic lack of communication between facilities and IT personnel, and serious problems of this nature could plausibly occur in any organization where these important functional groups are not aligned and in operational harmony.

Factoring IT Equipment into the Design of New Buildings

According to the Whole Building Design Guide (WBDG, 2008), "integration of information technology and building architecture calls for a robust, global, and secure infrastructure that will support the growing and evolving demands of business and government in the 21st century". This is a promising sign, as it implies that the needs and impacts of IT (and also telephony) equipment are finally becoming a central factor in the design of new buildings. As this practice becomes more integrated in the planning process, it will continue to minimize the potential for costly upgrades to electrical infrastructure in the years following the completion of a new building. As John Melchi, Sr. Associate Director for Administration at the National Center for Supercomputing Applications, states, "if you want to bring your… Project in on time and on budget, get the design right the first time" (Melchi, 2008).

Solving the IT Energy Problem

While the nature and scope of the IT energy problem is clear, the question about how to deal with it is a bit more complicated. While portions of the solution have been highlighted in the discussion above, complete resolution requires a holistic, interdisciplinary approach that involves consumers, manufacturers and regulators alike. In general terms, there are three basic areas to address: transform the IT manufacturing industry so that it incorporates energy efficiency and power quality as a core part of its product development platform; transform procurement behavior on the part of consumers of IT equipment so that 'green' products are a purchasing requirement; and, transform IT management practices to insure that devices are managed for power efficiency during their active life cycle.

MARKET TRANSFORMATION PROGRAMS & CHANGING REGULATIONS INFLUENCE MANUFACTURER BEHAVIOR

At the heart of most of the issues pertaining to IT impacts to electrical infrastructure are those surrounding the historic lack of communication between IT managers and energy/facilities managers. However, in a broader context communication problems have also existed between manufacturers of IT equipment and their customers. Manufacturers, whose primary motivation is to sell more equipment, have been slow to accept the fact that the devices they sell often carry a variety of unintended consequences for their customers. Clearly, makers of computers, servers and other IT devices don't intend for their devices to overwhelm electrical infrastructures at their customer facilities. But until recently, anecdotal data suggest that the topic was considered so volatile that standard practice was to simply avoid it altogether… A practice that in part has led to the substantial set of problems that many organizations now face. Further, until recently regulators and standards organizations have also been slow to address this rapidly escalating problem. All of this is changing, however, for the good of consumers, for manufacturers and for the environment.

MARKET DRIVEN PROGRAMS DRIVE INDUSTRY CHANGE

Transforming the electronics market has become an objective of government organizations, electric utilities and energy efficiency organizations. However, creating progressive market driven programs for the IT industry has been a task easier said than done. In 2004, a breakthrough occurred. Ecos Consulting, through a grant by the Natural Resources Defense Council and the California Energy Commission, conducted a research project that indicated that by simply improving the energy efficiency and power quality of power supplies – the common denominator in all electronic products – significant energy savings could be achieved without prohibitive cost incursions for manufacturers. Ecos and its other partners in this research effort discovered that improving power supply efficiencies allowed savings to be garnered in all phases of a computer's operation, including all active and low power states. Most power supplies sold on the market at the time of the research were remarkably inefficient, wasting 10-70 percent of the total energy consumed by the finished product (Calwell & Reeder, 2001).

In response to this landmark study, in 2005 the 80 PLUS program was created by Ecos and a new standard for what constitutes an energy-efficient power supply was set. By partnering with electric utilities and market transformation organizations, 80 PLUS established a unique pool of market-based incentives to encourage manufacturers to begin using power supplies that met the new standard. The original 80 PLUS specification stipulated that a power supply must be at least 80 percent efficient or greater at various load thresholds and be power factor corrected to at least 0.9. Compared to prior models typically available on the market, an 80 PLUS certified unit saved 85 kWh per year in a computer and 301 kWh per year in a desktop derived server. This standard was ultimately adopted in total by ENERGY STAR in the 4.0 revisions to the computer specification standards (US EPA, 2007), and has now evolved to include even greater levels of energy efficiency.

Another innovative program that is motivating both manufacturer and consumer behavior is the Electronic Product Environmental Assessment Tool, or EPEAT. EPEAT, which is a program of the Green Electronics Council, is "a system to help purchasers in the public and private sectors evaluate, compare and select desktop computers, notebooks and monitors based on their environmental attributes. EPEAT also provides a clear and consistent set of performance criteria for the design of products, and provides an opportunity for manufacturers to secure market recognition for efforts to reduce the environmental impact of its products ("EPEAT").

Programs such as 80 PLUS and EPEAT, particularly when paired with evolving Energy Star specs, are creating market conditions that are motivating manufacturers to compete on energy efficiency and environmental attributes, rather than simply on price or other performance criteria. They are also allowing progressive manufacturers to change the nature of the conversation that they have with customers to include the energy impacts associated with their equipment, and to help customers tackle those impacts head on. As stated by John Snaider, HP's Vice President of Americas responsible for Business PCs, 'our commitment to greening our PCs is demonstration that the desktop (computer) is no longer a commodity product (Snaider, 2007)"

GREEN PROCUREMENT

If it is the responsibility of manufacturers to build more efficient IT devices, it can also be said that it is the responsibility of consumers to buy them. If IT energy efficiency is to continue to progress, it will be incumbent on public and private organizations to prioritize energy efficiency and other environmental attributes in their procurement specs. Government organizations are generally required to standardize on the prevailing ENERGY STAR specification, which is greatly improved since the changes in 2007. However, private organizations are not held to that same standard, and still make decisions on a variety of criteria. Unfortunately for some, prioritizing energy attributes may not be as straightforward as it seems on the surface.

Much as manufacturers are often forced to make design choices based primarily on cost, so too do procurement personnel often make buying decisions based primarily on price. This is particularly true in times of economic turmoil and cost-cutting initiatives, when every dollar is tightly controlled and budgets are managed for the short term. Unfortunately, this scenario does not serve energy efficiency needs well, nor does it generally serve the financial needs of the organization in the longer term. As discussed in previous sections, procuring efficient equipment carries with it a number of short and long term benefits. First, there is an immediate operating cost reduction attributable to more efficient devices. There is also a longer term benefit that could be even more compelling, even if harder to quantify. According to research by Ecos Consulting, purchasing computers that contain 80 PLUS certified power supplies can have a direct impact on electrical infrastructure in existing buildings. "Higher power factor reduces current draw and allows more computers to be operated on the same branch circuit without the need for costly infrastructure delays (Ecos, 2005)". The research goes on to point out that similar benefits can be seen when considering IT procurement practices in new building construction, where "smaller and less expensive distribution systems can be constructed when 80 PLUS computers are considered in the planning process". And, of course, there are

tremendous environmental benefits that accompany any green buying decision, which is a value that cannot be overlooked.

ACTIVE POWER MANAGEMENT AND MEASUREMENT OF IT DEVICES

While improvements to hardware efficiency and procurement of efficient equipment are essential, the bulk of IT energy waste occurs during the active life of the equipment due to the absence of IT power management. In 1997, a paper titled "User Guide to Power Management for PCs and Monitors (Nordman, etal, 1997)" was commissioned by the Federal Energy Management Program and US Environmental Protection Agency. The findings were stark, and indicated that the lack of adoption of PC power management could cost U.S. businesses $1.75 billion by the year 2004, a staggering amount that did not even begin to account for detrimental impacts to building infrastructure, most notably HVAC systems. Due the proliferation of PCs in the modern marketplace, the scope of this problem is now much larger than the initial research might have indicated. In fact, the Commercial Energy Business Consumption Survey (US DOE, 1999) indicates that the numbers of PCs in commercial settings skyrocketed by 35 percent at the end of the decade, and PC shipments from manufacturers have increased steadily in the years following.

Despite the fact that nearly all modern PCs have the capability to shift to a low power state when not in use, the vast majority of these devices do not do so. In fact, it is estimated that more than 40 percent of the monitors in the commercial marketplace never utilize low power states, and Lawrence Berkeley National Laboratory (LBNL) field surveys indicate that as little as 6 percent of computers in non-residential settings have power management enabled (Nordman, etal, 1997). Further, a disturbing trend has developed in that IT departments are increasingly mandating that PCs NEVER be shut down so that they are accessible 24/7. For a typical commercial or institutional energy consumer, this presents an incredible opportunity to save enormous amounts of energy and operational cost each year simply by properly managing these devices.

MARKET TRANSFORMATION ORGANIZATION HELPS CREATE A NEW CATEGORY OF ENERGY SAVING PRODUCTS

It has often been said that you can't manage what you don't measure. In 2001, the Northwest Energy Efficiency Alliance (NEEA) was approached with the opportunity to provide development funding to Verdiem Corporation, at the time a young start-up seeking strategic funding upon which to build its business. NEEA was immediately intrigued by the opportunity, and agreed to provide funding pending one technical stipulation: that Verdiem integrate measurement and verification (M&V) into the product as a core piece of its functionality (Degans, 2002). This requirement simultaneously demonstrated the desire of utilities to achieve energy reductions in IT equipment use, while also addressing the fundamental concerns of measurement, equipment transience, and savings persistence.

Working with the Regional Technical Forum of the Bonneville Power Administration, early analysis by NEEA revealed that Verdiem's product could save 200 kWh per computer year in a typical setting (BPA, 2004). Yet, only after it was demonstrated that IT equipment could be accurately measured, tracked and managed for the long term did NEEA agree to support the launch of Verdiem. The investment made by this utility-funded organization not only launched the first and most sophisticated power management product, but it helped create a new genre of computer software products that are critically important in helping IT managers and facilities managers quantify and manage IT-related energy load.

AN UNTAPPED OPPORTUNITY FOR COMMERCIAL AND INSTITUTIONAL CONSUMERS

Why power management functionality is largely unused has been the topic of much research in the past decade. To be sure, it is attributable to a number of factors, but the most pressing seem to be these: most organizations still don't understand how much energy and money is associated with powering IT equipment; IT doesn't own the energy bill, and therefore is often unmotivated to embrace power management as a 'cost cutting' initiative; IT is primarily concerned with maintaining network usability and keeping the enterprise functional, not with energy efficiency; and, most are simply still unaware that sophisticated software tools now exist that can balance all of these concerns and deliver tremendous value (financial, informational and manageability) to their organization.

Fortunately, as energy rates rise, as the economy softens, and as organizations strive to achieve savings from every portion of their operation a spotlight is increasingly being shined on IT energy waste, and as a result the opportunity surrounding network power management is becoming increasingly visible. Modern network power management software allows computers to be managed with organizational consistency in much the same way that other building systems such as lighting or HVAC are governed by energy management systems, but with even more granularity of data and built in reporting capabilities.

Summary & Conclusions

IT energy consumption is one of the most prevalent, and until recently, least understood energy problems facing most commercial and institutional entities. The problems extend beyond those directly related to the energy consumed by these devices, and often include significant cross-effect impacts to electrical infrastructure and other mechanical systems, such as HVAC.

To address these problems, regulators and standards organizations should continue to develop innovative and thoughtful programs that help lead manufacturers to new levels of efficiency. For their part, manufacturers should continue to embrace energy efficiency in its product development efforts and to educate consumers about how to best procure and manage devices for maximum efficiency. And commercial and institutional consumers must work to continue to understand how operation of IT devices impacts their facilities and their bottom lines, as well as to implement common sense solutions.

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