Green and Sustainable Information Technology: A Foundation for Students

Thomas A. Pollack
Duquesne University
600 Forbes Avenue
Pittsburgh, PA 15282
412.396.1639
pollack@duq.edu

Abstract

Seldom does a day pass in which we don't hear or read about sustainability or "going green." Environmental concerns are constantly in news headlines, and the impact of technology on our environment is significant. Large technology organizations such as Dell, HP, ISM, Sun, Hitachi, and Fujitsu have introduced green and sustainable initiatives. "Green" is generally understood to mean "Friendly to the environment and energy efficient." Sustainable implies planning and investing in a technology infrastructure that serves the needs of today as well as the needs of tomorrow while conserving resources and saving money. Organizations are quite concerned with environmental issues, but they have also come to realize that sustainable business practices can significantly enhance the bottom line. This paper will discuss the features of green and sustainable information technology practices, and suggest a basic knowledge foundation that will serve our future technology professionals.

Introduction

In a recent Info World article, author Ted Samson drew a distinction between "green" versus "sustainable" technology (2007). Frequently we hear the terms being used interchangeably, but technically there should be a distinction. "Green" generally means "environmentally friendly" and energy efficient. On the other hand "sustainable reflects planning and investing in a technology infrastructure that will serve today's and tomorrow's needs while helping to save money on wasted resources such as energy and paper." Thus the use of green technology helps to ensure sustainability (Samson) and thus the interrelationship between the two terms.

GreenerComputing.com (2008) reports that a recent industry survey indicated that at least 65 percent of IT Managers are employing energy efficiency measures in some form to reduce costs and environmental impact. Among the leading practices being employed are the following:

- Use of blanking panels to minimize recirculation of hot air (65%);
- Sealing the floor to prevent cooling losses (56%);
- Identification of hotspots and optimization of airflow within the facility (25%).

The survey compiled by GreenerComputing (2008) also reports the following obstacles:

- Lack of top management encouragement (40%)
- Unawareness of cost/benefit relationship of energy efficiency (36%)

- Fear of risking reliability (35%)
- Lack of communications between IT and facilities departments (33%).

One problem with the greening of IT is that it forces organizations to buy more. Plans usually call for things like more energy efficient servers, intelligent sensors for data center cooling, server virtualization software, low power monitors and devices that turn off dormant computers (Baines, 2007). This implies significant capital outlays before any gains are realized. Of course, organizations are then forced to evaluate the bottom line impact and payback period for such investments, independent of vendor and consultant claims (Baines). Dave Douglas of Sun Microsystems contends that power consumption of data centers doubled between 2000 and 2005, and energy costs consume 25% of an IT budget. He opines, therefore, that what is good for the environment is also good for business. The EPA estimated that servers and data centers across the nation consumed more than 61 billion kilowatt hours of electricity in 2006 at a cost of about $4.5 billion. This is more than the electricity consumed by all the nation's color televisions and similar to the amount consumed by 5.8 million households (Marsan, p.26). Douglas predicts that by 2009, one third of IT organizations will have "improved environmental sustainability" as a top IT management objective (2006).

However, there is ambivalence as to the reasons for green initiatives. Only 30 percent of respondents to a recent E-Week survey indicated that economic considerations were the most important factor. The majority of respondents to this survey indicated that the green initiative is not part of their budget. One might conclude, therefore that IT professionals recognize the environmental impact of IT activities, but most businesses are not willing to spend additional money for eco-friendly measures unless there is a commensurate payback (Gibson, p.53). The two issues must go hand-in-hand.

Getting Started

Many organizations are expressing a buy-in to "sustainable" or "green" IT. They have come to generally understand these terms to describe the manufacture, management, use and disposal of information technology in such a way that minimizes damage to the environment. Gartner Research reports that power consumption by computers accounts for two percent of global carbon dioxide (CO_2) emissions, roughly equal to the carbon output of the airline industry (Walsh, 2007).

Walsh (2007) defines sustainable IT management and use as follows:

> "Sustainable IT management and use has to do with the way a company manages its IT assets. It includes purchasing energy-efficient desktops, notebooks, servers and other IT equipment, as well as managing the power consumption of that equipment. It also refers to the environmentally safe disposal of that equipment, through recycling or donation at the end of the lifecycle."

Converting to a "green data center" is not a simple task, but there are many suggestions and techniques available. Gibson (2008) indicates that "green IT" is still in its early stages. However, greenness is seeping into organizations even when there is no green initiative when more energy efficient equipment replaces older less efficient equipment. It is suggested that the conversion to a green process can occur in steps to reduce risks and also to produce benefits along the way (Dietrich, p.3). Typical data center inefficiencies result in the use of two to three times the power required for IT equipment because typical designs are oversized for maximum capacity, and older infrastructure components are very inefficient; thus total cost of ownership for data center facilities and IT systems is excessive (Dietrich, p. 4). Considerable research has been done on devising plans to convert to a "green IT environment," and therefore when an organization is ready to convert, prescriptive guidelines and suggestions are available.

A set of recommended factors for consideration to begin the conversion to a "green data center" include the following (Dietrich, p.8):

- An inventory of your current systems, their power usage and locations
- Your company's business and growth plans -- to help forecast future needs
- Current or planned governmental energy efficiency regulations in your area
- Available energy efficiency rebates or economic incentives from government sources or your energy provider
- Any already established goals for reducing your company's carbon footprint -- and the timeframe set for achieving those goals.

Complementary to the above, Mines (2007) recommends four steps for the creation of a "Green IT Action Plan." These steps are stated in general terms and might be considered as a blueprint for migration to "green IT." The recommended steps include the following:

- Indentify and prioritize the goals of a green IT initiative
- Assess the current situation relative to high-priority goals
- Find and execute quick wins
- Craft and communicate an action plan

Mines' Forrester Research publication then proceeds to recommend a four section format for an action plan. The sections recommended for the action plan are (p. 7):

- Revising processes and metrics
- Optimizing efficiency of existing IT assets
- Revamping architecture and infrastructure
- Positioning IT to enable green business practices

The above points, when taken into consideration, should be helpful in providing organizations with a starting point and a framework for beginning the move to a green and sustainable IT organization.

Challenges

The point has been made that there have been significant increases in power consumption in data centers since 2000. Weinberg reports the following breakdown of usage derived from a power study conducted by the Emerson Network (p. 34):

- Air Conditioning 50%
- Servers and Storage 26%
- Communication Equipment 11%
- Power Distribution Equipment 10%
- Lighting 3%

In terms of global CO_2 emissions, Simon Mingay, Gartner analyst provides the following breakdown in accounting for emissions (Weinberg, p. 34).

- PCs and Monitors 40%
- Servers 23%
- Fixed-line Telecommunications 15%
- Mobile Telecommunications 9%
- LANs and Office Telecom 7%
- Printers 6%

The above charts provide a good indication of the biggest problem areas from an energy and CO_2 perspective. The remaining sections of this paper begin to explore some of the measures individuals and organizations can take to initiate the move to a "green IT" environment.

Energy efficiency improvement measures can range from a series of simple and inexpensive actions to much more expensive infrastructure upgrades. Some of the simpler and less expensive measures include:

- Blocking cable openings to prevent cold air waste in the hot aisle
- Removing under-floor cable blockages that impede airflow

- Turning off servers that are not doing any work
- Turning off computer room air conditioning (CRAC) units in areas that are over provisioned for cooling (Dietrich, p. 9).
- Data deduplication (scouring data for redundant instances and eliminating them – cutting storage needs for the same data by 50 percent or more) (Gibson).
- Printing less and more efficiently (Mitchell, 2008).
- Employing intelligent cooling by cooling only when necessary (Baines, 2007).
- Turning off PCs when not in use (Baines).

Power and cooling efficiency, in conjunction with reducing the heat generated in the data center can serve to increase energy efficiency without a large upfront investment. For example, improvements in rack and room layout can lead to significant energy savings (Dietrich, p.10). Thermal mapping tools can help identify hot spots and cold spots. Once identified, in-row, on rack cooling systems can be designed so that cold air can be brought just to hot spots or server aisles can be rearranged so that air conditioning is aimed at hot aisles (Walsh, 2007).

The following opportunities for improved energy efficiency have been identified:

- Organizing IT equipment into a hot aisle and cold aisle configuration
- Positioning the equipment so that you can control the airflow between the hot and cold aisles and prevent hot air from recirculating back to the IT equipment cooling intakes
- Leveraging low-cost supplemental cooling options -- such as water or refrigerant heat exchangers
- Improving rack cooling efficiency by employing a rear door heat exchanger or an enclosed racking system to dissipate heat from high-density computer systems before it enters the room.
- Taking advantage of the current capacity by clearing under-floor blockages and implementing effective cable management
- Ensuring that floor openings match the equipment thermal load by adding or removing perforated tiles at the equipment air intakes
- Considering the addition of ducted returns (Dietrich, 2007)
- Purchasing low power processors that do not generate as much heat (Baines, 2007)
- Retrofitting offices with motion sensors that shut off lights if there is no motion (Gibson, 2008)

It becomes quite apparent that data centers and their significant energy usage are attracting a great deal of attention. It is not uncommon to have a roomful of servers running at 10 percent utilization. Virtualization is a hot issue because it can help consolidate servers, run the data center more efficiently, and allocate server resources to match business requirements (Weinberg, p.33). Virtualization is technology for everyone, not just the large organization. It yields cost reductions via server consolidations and makes effective use of underutilized hardware, thereby requiring less power and cooling (Coyotepoint, p.2).

According to a recent survey by Chadwick Martin Bailey, the top five reasons for implementing server virtualization are (Weinberg):

1) Consolidation of server utilization
2) Lower data center operating costs
3) Improved disaster recovery and backup capabilities
4) More effective software development and testing environment
5) Lower IT administration costs

Virtualization however adds a layer of complexity to the data center. This compounds a concern expressed in a Computerworld survey where nearly 70% of the respondents indicated that their current staffers do not have the skills to manage the complexity of their data centers (Hall, P. 24). Vendors have also been improving server efficiency through more efficient chips and power supplies. Organizations can use the Electronic Product Environmental Assessment Tool (EPEAT) developed by the Zero Waste Alliance to evaluate purchases. Products meeting the EPEAT standards have smaller levels of mercury, cadmium and lead, are more energy efficient and are easier to recycle. They also carry the EPA's Energy Star 4 label.

Power management tools that shut down or put machines in sleep mode can also be employed to save energy (Walsh). PCs and monitors are the biggest problem, but the most difficult to address because it is difficult to control user behavior. Gartner's Simon Mingay suggests low power use or off at the end of the day and the use of power management features. He estimates CO_2 emissions and related power costs from operations of PCs could be cut by as much as 40 percent (Weinberg, p. 34).

Disposal of IT equipment is also a matter of significant importance. Environmentally responsible disposal of used and obsolete equipment has taken on added importance in recent years. Most computer equipment managers offer take-back programs and therefore assume responsibility for proper disposal. Dell and Sony take back their products for free and Toshiba will take back laptops. Apple and HP charge a fee, but will credit to future purchases. There are also companies that will dispose of IT equipment for a fee. It should be noted that only about one-third of all U.S. companies have an IT asset disposal policy (Walsh, p.6).

Data centers are among the hardest commercial buildings to make energy efficient because computer systems require so much electricity and give off so much heat. The challenge in meeting the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards is the energy load. Earlier versions of LEED standards excluded energy used for data processing, but latest versions (2.2 and higher) don't permit this exclusion (Marsan, Buildings Go Green).

To cut energy usage with new data centers, the following measures are effective (Marsan, p.22):

- Build using locally supplied and recycled materials
- Minimize waste during construction
- Use lots of windows for extensive natural lighting
- Use fluorescent lighting with dimming throughout
- Use occupancy sensors to automatically control lights and temperature
- Use raised flooring with under floor heating and cooling throughout, not just in computer rooms.

Most green buildings don't look like typical office buildings. They often have stark, modernistic designs and are made of space-age materials. On the inside, there are typically large open spaces with movable wall systems and modular furniture. Green buildings typically don't have electric outlets in the wall, but instead have in-floor boxes to provide power and data communication. They have fewer electrical outlets so employees can't have coffee pots, hot plates, microwaves, or refrigerators. Also, there are no personal heaters, fans or desk lamps. The general rule is two coffee pots for every twelve people. A coffee maker uses about 1000 watts to brew and it cycles on and off. A hot plate is a constant 250 watts. Green data centers usually eliminate personal printers for most employees and create shared printing and copy rooms on each floor vented directly to the outside to keep it cool. Adjustment is difficult for employees who have been accustomed to a private office and now work in a large open space. Positive features of green buildings include lots of natural light, making maximum use of sunlight, fluorescent lights with automatic dimmers that adjust to sunlight and turn off when the room is unoccupied, and all employees positioned within 65 feet of natural light. The biggest complaints involve loss of personal printers, copiers and coffee pots (Marsan, Buildings Go Green).

In an effort to conserve energy, Verizon has replaced 7,000 PCs in call centers with Sun Ray thin clients and has also begun a company-wide migration to LCD monitors. The thin clients use about 30% less power than PCs and Verizon's overall savings is in the neighborhood of $900,000 annually (Mitchell, 2008).

Research firm IDC estimated 900 million desktops in use worldwide in 2006. Even if all units were Energy Star 2006 compliant, they would consume 426 billion kilowatt hours of power annually. If the equipment met the 2007 Energy Star specification, power consumption would be 27% lower. That would save enough energy to power all of Switzerland for nearly two years and cut greenhouse gas emissions by about 178 billion pounds (Mitchell, p.21).

Mitchell goes on to suggest five tips to achieve a greener desktop (p.22). They include:

1. Do an energy audit. Some organizations have learned that computer equipment was consuming nearly as much power after hours as it was during work hours.

2. Adopt and enforce power management. The greatest power savings is realized when you get systems to go to sleep. Lenovo recommends a configuration whereby laptop disk drivers spin down after five minutes of inactivity, monitors go blank after 10 minutes and machines go into standby mode after being inactive for 20 minutes.

3. Dump your CRTs. They are your biggest offenders and upon replacement with more efficient LCDs, which use about one-third the power, will produce substantial savings in electricity costs.

4. Slim down the client. Select desktop computers that are Energy Star 4.0 compliant. Energy Star- rated equipment can save energy and space and decreased power consumption will significantly reduce the need for cooling in office areas. Replace PCs with thin clients where possible.

5. Print more efficiently. Energy Star labeled models can cut energy costs by as much as 5%.

Conclusion

The U.S. Federal Government, which has tracked energy usage in buildings for more than 20 years, is spearheading the green data center movement. The EPA reported to Congress that the amount of electricity used in data centers more than doubled between 2000 and 2006 (Marsan, Green Data Centers). Gibson (2007) stated that sharp spikes in data center energy use have captured the attention of IT executives. However, Gartner Group analyst Simon Mingay reports that "most organizations may choose to paint it green, but the reality is they're focused on saving energy and therefore money. And their willingness to cut CO_2 emissions is significantly limited to their interest in cutting their electric bill (Gibson, p. 46). Thus it is widely recognized that IT professionals recognize the environmental impact of IT activities, but most businesses are not willing to spend additional money for eco-friendly measures unless there is a commensurate payback (Gibson, p.53).

Organizations moving toward a "green data center" can classify actions taken as major, requiring infrastructure changes and significant costs or minor requiring less costs but sometimes significant efforts to change long-established habits and ways of doing things. Simple changes can make a difference.

It is the author's contention that our IT-related educational programs need to develop as strong sense of both the major and minor initiatives that can be undertaken to achieve a "green and sustainable" IT environment. Higher education must also demonstrate a sense of commitment to these practices through demonstrated actions. Colleges and universities are charged with the awesome task of developing the leaders of tomorrow. Building a strong sense of awareness of green and sustainable practices may produce some magnificent ideas for conservation of energy and preservation of our environment.

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