Paige Laura Epler

IT 103, section 012

8 October 2010

Research Paper:

Green Computing – History, Methodologies, Benefits and Barriers

"By placing this statement on my webpage, I certify that I have read and understand the GMU

Honor Code on http://academicintegrity.gmu.edu/honorcode/. I am fully aware of the following

sections of the Honor Code: Extent of the Honor Code, Responsibility of the Student and Penalty.

In addition, I have received permission from the copyright holder for any copyrighted material that

is displayed on my site. This includes quoting extensive amounts of text, any material copied

directly from a web page and graphics/pictures that are copyrighted. This project or subject

material has not been used in another class by me or any other student. Finally, I certify that this

site is not for commercial purposes, which is a violation of the George Mason Responsible Use of

Computing (RUC) Policy posted on http://universitypolicy.gmu.edu/1301gen.html web site."

CoSign Digital Signature

Introduction

Green computing, also known as Green IT, is the study and practice of environmentally responsible use of information technology. It involves such practices as energy management, the use of recyclable materials, virtualization, and the specific employee procedures and habits.

Every successful company, composed of various functional departments, must attract and retain capable employees, comply with legislation and regulations, and satisfy shareholders. To attract customers, in order to generate more revenue and increase profits, companies must reduce costs and produce better, more desirable products and services. In addition to these quantitative measures, it is also increasingly necessary for commercial endeavors to pay attention to public relations, and to demonstrate social responsibility (Feretic, 2010). Green computing is a relevant approach that an information technology department can use to contribute to the strategic and tactical corporate objectives.

Green IT can contribute significant benefits to the environment, a company, and its employees, however there are barriers that must be overcome by any organization that wishes to implement it.

History

The widespread deployment of IT has had inadvertent side effects, such as increased energy consumption and pollution. Technology-related power consumption is rising rapidly. According a recent U.S. Environmental Protection Agency (EPA) report, "the IT industry consumed approximately 61 billion kilowatt-hours of electricity in 2006. That's 1.5% of the total electricity consumed in the United States. The power bill is roughly $4.5 billion. Servers and data centers deployed by the U.S. Federal Government account for about 10%, or 6 billion kWh, of the total consumption" ("Green computing and D-Link," 2009).

Accordingly, awareness of these effects has brought about a practice called "the greening of IT." The concept of green computing got its start in 1992 when the EPA created its Energy Star program, which labeled electric products, such as refrigerators and air conditioners that minimized energy consumption while maximizing efficiency. This was revised in October 2006 to include more stringent requirements for computer equipment efficiency ("ENERGY STAR Program requirements for computers," 2006). In 1997, the United Nations' Kyoto Protocol mandated the reduction of carbon emissions and required manufacturers to calculate the electricity used by the computers. Next, in 2003, the European Union adopted a Restriction of Hazardous Substances (RoHS) which restricted the use of specific toxic materials in the manufacture of electronic equipment. In 2006, the United States passed Public Law 109-431 to study and promote the use of energy-efficient computer servers. Subsequently, in 2007, President George W. Bush issued Executive Order 13423, which required all United States Federal agencies to use the Electronic Products Environmental Assessment Tool (EPEAT), a set of standards aimed at increasing the efficiency and life of electronic products, when purchasing computer systems (Bush, 2007).

Methodologies and Benefits

The overall goals of green computing are similar to that of any other ecologically-friendly endeavor: chiefly, to maximize energy efficiency, reduce the use of hazardous materials, and promote the recycling of obsolete products and waste. Various practices that deliver useful benefits have become popular.

Energy management is often the starting point in implementation of green computing. In line with new ecological awareness, many companies have also come to accept that reduced energy consumption translates not only to reduced greenhouse gas emissions, but reduced operational costs for the business as well. Fortunately, there are steps that can be taken to manage and reduce energy consumption. Servers and entire data centers can be consolidated. The data

center can upgrade to energy-efficient servers and high efficiency power supplies, and can employ power management processes and controls that automatically turn off systems after set periods of inactivity. User computers are also high energy consumers. "Fifteen PCs can generate as much carbon emissions as a mid-size car each year. The average PC consumes 588 kilowatt-hours of electricity per year, and wastes almost 400 kWh of that by running at full-power when not in use. Using power management controls on PCs during periods of inactivity can cut energy use on average 60-70 percent" (Klustner, 2008). Desktop computer power supply units (PSUs), which are generally inefficient and dissipate a certain amount of energy as heat, should be replaced with newer models.

Virtualization, of both computer resources and the employee experience, has started to generate significant benefits for green computing. Computer virtualization refers to an abstraction of computer resources --- for example, running two or more logical computer systems on one set of physical hardware. With virtualization, hardware infrastructure is reduced, resulting in reduced energy and cooling consumption. Cloud computing services, relating to the location and ownership of infrastructure, can be purchased from a third-party provider, resulting in economies of scale and significant cost savings. In addition to virtualization of computer resources, virtualization of the employee experience can also drive benefits for the environment, the company and the employee. Telecommuting, teleconferencing and telepresence technologies are good examples of this. These practices can reduce travel costs, increase worker satisfaction and, through a reduction of facilities requirements, reduce energy consumption and generate significant savings through lower overhead costs for office space, lighting, heat, and the like. According to the EPA, the average annual energy consumption for U.S. office buildings is over 23 kilowatt hours per square foot, with heat, air conditioning and lighting accounting for 70% of all energy consumed (U.S. EPA, Office of Air and Radiation, 2008).

Certainly one of the basics of green computing involves recycling. The EPA estimates that as of 2007, some 66 million PCs, 42 million monitors and 25 million printers/faxes/scanners were in storage. The EPA further estimates that only about 18% of these would be recycled, with the rest disposed of in landfills (Tucci, 2008). Recycling computer equipment can keep toxic materials such as lead and mercury out of landfills, and can also replace equipment that otherwise would need to be manufactured, thus reducing further energy requirements. Computer systems that have aged or become obsolete can have their lifecycles extended or re-purposed. For example, older servers can be kept powered off or in standby, and used only during periods of high demand. Older desktops can be used as terminal servers, or can be provided to employees whose jobs do not require high-end computing power. Older computer equipment can also be donated to various charities and non-profit organizations.

Finally, within the realm of green computing, there are many practices and work habits that can be encouraged, or mandated, among employees. Most computer equipment now comes with power management features and they should be activated. Computers, printers and monitors should be turned off when not in use. Printers, and hardcopy print output, can be especially hard on the environment. Users should review documents on screen, rather than printing documents unnecessarily, especially draft versions. Many printers can print double-sided documents, which is also environmentally friendly. Ink-jet printers, though a little slower than laser printers, use 80 to 90 percent less energy ("Go green, save green," 2010). Many organizations mandate the recycling of paper, which is an excellent practice. Companies should carefully consider the size of computer monitors provided to employees. A large display device, such as a 17-inch monitor, uses 40 percent more energy than a 14-inch monitor. Also, if a monitor is set to display higher resolution, it requires more energy ("Go green, save green," 2010).

Barriers to Implementation

As indicated above, there are many benefits to green computing. Unfortunately there are barriers that a company has to overcome in order to successfully implement green computing. First is the natural psychological resistance to change on the part of any organization. The larger the organization, the more difficult it is to justify and manage change. Green computing can justify some significant cost savings and increased profits, but there are also "soft benefits," such as environmental awareness, that are more difficult to recognize and quantify. Cloud computing is difficult for many companies to embrace as they apparently still feel the need to "own" the infrastructure and resources, rather than "rent" them from a third-party provider (Barnhart, n.d.).

Another overwhelming barrier can be that of cost. Most companies, particularly in times of a weaker economy, find it hard to justify expenditures on information technology, which is often viewed as a cost center, rather than a business enabler. It can be very challenging to construct a cost-benefit analysis that adequately demonstrates how information technology contributes to the bottom line. Certainly a comprehensive return-on-investment analysis that shows how, for example, reduced energy or travel costs can increase the profit margin, is imperative. Internal recycling, or re-purposing of computer equipment, can also contribute to cost reductions and thus improved profit margins. Many states have enacted specific laws relating to the disposal of certain types of electronic equipment in landfills, and companies view this as a cost increase, rather than a cost reduction.

Green computing is still relatively new and it is not easy for organizations to understand and articulate their requirements. Although it is desirable to purchase computer equipment from suppliers and vendors that are ecologically mindful in their manufacturing processes, this can be challenging to accomplish as many manufacturers lack environmental awareness.

Conclusion

Despite the barriers, green computing is gradually becoming more popular. In most commercial endeavors, consumers are increasing the demand for eco-friendly products. There is a vast amount of computer equipment manufactured worldwide. This, coupled with the widespread use of information technology has had a direct impact on the environment. The goal of green computing is to reduce the negative impact of computer resources on our natural resources.

To accomplish this, companies that implement green computing purchase and deploy information technology equipment that is manufactured with environmentally-friendly chemicals and materials. They deploy computer equipment that uses less energy, and they utilize processes to positively manage energy consumption. Companies are moving to various methods of virtualization that require less computer resources to accomplish the same tasks. They attempt to recycle or re-purpose obsolete computer equipment, or to dispose of the equipment in an ecologically-sensitive manner when the equipment cannot be recycle. These companies also encourage their employees to adopt habits and practices that help to reduce the organization's environmental footprint.

Organizations that have adopted green computing methods demonstrate how Green IT can reduce costs in a company, and increase the profit margin. Additionally, if a company demonstrates corporate responsibility and is perceived by the public as being environmentally responsible, this can attract more customers and increase revenue.

 "Sustainability, corporate responsibility, and greening business practices have jumped from social movement to business imperative. Green IT is a dynamic, strategic, and ethical framework of practice for all IT. Green IT is about doing what it takes to be innovative, agile, efficient, responsive, profitable and responsible all at the same time" (Baroudi, Hill and Reinhold, 2009).

References

Barnhart, B. (n.d.). *Cost saving ideas for companies like cloud computing*. Retrieved October 1,

    2010, from http://ezinearticles.com/?Cost-Saving-Ideas-For-Companies-Like-Cloud-

    Computing&id=4464946

        Ezine article that analyzes cloud computing as an information technology best

        practice cost saving technique, but argues that many businesses have not

        implemented cloud computing because they do not understand the technology or

        recognize the benefits, and thus are losing money unnecessarily. Promotes the

        position that the greatest barrier to the implementation of cloud computing is that

        many companies are reluctant to give up control of their assets and resources.

Baroudi, C., Hill, J., & Reinhold, A. (2009). *Green IT for Dummies*. Hoboken: Wiley

        Comprehensive book in the "Dummies" series written in easily understandable

        terms. The book provides an overview of green IT, addresses what the concept can

        do for technology, the environment and businesses. It also discusses major

        components and solutions for green IT, and summarizes how businesses can rollout

        these technologies and methodologies.

Bush, G. "Strengthening federal environmental, energy, and transportation management."

    Executive Order 13423 of January 24, 2007. Retrieved October 3, 2010, from

    http://www.epa.gov/oaintrnt/practices/eo13423.htm

        Federal Executive Order signed by President Bush on January 24, 2007 revokes

        earlier greening orders and is intended to improve the Federal impact on

        environment, energy and transportation management. Provides specific

        instructions for reducing energy intensity, increasing use of renewable energy,

        reducing water intensity and designing and operating sustainable buildings.

Requires all United States Federal agencies to use EPEAT (Electronic Products Environmental Assessment Tool) when purchasing computer systems

Cobourn, B. (2008). Going green: Sustainable growth strategies; *Technology Executive Connections, Volume 5*. PriceWaterhouseCoopers.

Extensive survey compiled by PriceWaterhouseCoopers, the world's largest accountancy and professional services firm. The survey presents quantitative findings and analyses from an economic intelligence study conducted around the world. The study examines how concern over climate change is affecting the technology industries, and links to the plans of many companies to meet the demand for environmentally friendly products and services.

Dahan, U., & Model, G. M. (2008). Green computing. *The Architect Journal #18*. Microsoft.

Publication by Microsoft Corporation's Platform Architecture Team designed to help refocus IT leaders on efficiency and total cost of ownership in terms of energy and the environment. Provides system recommendations on IT infrastructure system design, data center and server consolidations, applications development and rationalization, virtualization and efficient energy usage.

ENERGY STAR Program requirements for computers, version 4.0. (2006, October). Retrieved October 1, 2010, from http://www.energystar.gov/index.cfm?c=revisions.computer_spec

Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that proves recommendations and energy guidelines for electronic products. Started in 1992, the program was revised in 2006 to include more stringent requirements for computer equipment efficiency. The new guidelines particularly advocate power management features on computers.

Feretic, Eileen. (2010, July). Green stands for more than money. *Baseline,(105), 8*. Retrieved

October 1, 2010, from ABI/INFORM Trade & Industry.

http://www.baselinemag.com/c/a/IT-Management/Green-Means-More-Than-Money-

463889/

Advocates the position that green computing is important, but that cost reduction

and profit increase should not be the only motivators for companies. Points out that

environmental and cultural reasons for green computing are equally as important

and should be used to persuade top management to support green initiatives.

Go green, save green: The benefits of eco-friendly computing. (2008). Retrieved October 4, 2010,

from http://www.apcmedia.com/salestools/SLAT-7DCQ5J_R0_EN.pdf

Presentation by an energy management company that operates in more than 100

countries worldwide. Discusses benefits of green computing, including cost saving

and energy reduction. Provides tips for ecologically-friendly computer use that can

be adopted by consumers of companies. Also suggests guideline for recycling and

disposal of computer equipment.

Green computing and D-Link: The green movement and specific D-Link solutions reduce

detrimental impacts on the environment. (2009, February). Retrieved October 3, 2010, from

http://whitepapers.techrepublic.com.com/abstract.aspx?docid=929351

Discussion of information technology methods and solutions that are

environmentally-friends, with suggestions as to how a business can migrate to

green computing. Also provides overview of history of green computing

movement, as well as short analysis of regulations and standards specific to green

computing.

Harris, J. (2008). *Green computing and green IT best practices on regulations and industry initiatives, virtualization, power management, materials recycling and telecommuting*. Brisbane: Emereo Pty Ltd.

> Rather than an in-depth analysis of green computing techniques and technologies themselves, provides best practice recommendations, tips and "secrets" centered around how to implement, and be successful, at green computing,. The book is intended for project managers or consultants who are charged with deploying green computing solutions.

Klustner, K. (2008). Top 10 reasons to green IT. *Environmental Leader*. Retrieved September 29, 2010, from http://www.environmentalleader.com/2008/02/05/top-10-reasons-to-green-it/

> Perspective from the chief executive officer of a company that provide enterprise software solutions to reduce energy consumption of PC networks. As to main reasons and benefits of environmentally friendly computing. Stresses that green IT sustainable practices can strengthen a company's reputation, improve employee morale, deliver cost savings and benefit the environment.

Oltsik, J. (2010, June). *What's needed for cloud computing? Focus on networking and WAN optimization*. Milford: Enterprise Strategy Group

> Discussion of cloud computing, contrasting vendor marketing hyperbole with realities of the technology. Defines cloud computing, identifies potential benefits and examines the role of network systems and connectivity in terms of deployment of this technology.

Rooney, P. (2010, August). *Gartner: Customers still don't get cloud computing*. Retrieved October 3, 2010, from http://www.zdnet.com/blog/virtualization/gartner-customers-still-dont-get-cloud-computing/2172

Summary of research study compiled by Gartner, one of the world's largest

information technology research and advisory firms. Analysis states that many

corporations still do not grasp the key benefits of cloud computing. These

companies do not recognize the cost and energy savings that can be derived from

cloud computing, but rather view it solely as an additional measure of IT security.

Stamper, J. (2010, June). The green IT myth. *New Statesman, 139(5005), 11*. Retrieved

September 30, 2010, from ABI/INFORM Global.

http://www.newstatesman.com/culturetech/2010/06/co2-energy-google-industry

Article summarizes the position that use of information technology generates

greenhouse gas pollution, as well as requiring increased energy consumption.

Highlights some quick fixes for individual computer users, but proposes that giants

in the IT industry, such as Google and IBM, must lead the way in their own

facilities.

Tucci, L. (2008). *E-waste: A blight on the environment and a company's good name*. Retrieved

October 3, 2010, from http://searchcio.techtarget.com/news/1329131/E-waste-A-blight-on-

the-environment-and-a-companys-good-name

A technology management strategy article that discusses disposal and recycling of

computer equipment (E-waste). Summarizes the adverse impact on the

environment of disposal activity, as opposed to recycling. Also points out the

dangers of providing used computer equipment to less advanced nations that may

have poor environment-related laws. Makes the case for the responsible disposal of

E-waste.

U.S. Environmental Protection Agency, Office of Air and Radiation. (2008). *Sector collaborative on energy efficiency accomplishments and next steps: A resource of the national action plan for energy efficiency*. Washington, DC: Government Printing Office.

> Federal report designed for property owners and managers identify cost effective opportunities for increasing energy efficient resources in the five commercial sectors of hospitality, retail, commercial real estate, grocery and municipal. The report describes the barriers to cost-effective energy efficiency, documents how energy savings are valuable investments for participating sectors, and identifies the tools needed for implementation and evaluation of cost-effective energy efficiency measures.

Varon, E. (2007, March). *Why green IT is better IT*. Retrieved October 3, 2010, from http://www.cio.com/article/100557/Why_Green_IT_is_Better_IT

> Article from CIO Magazine that uses a report on global warming issued in by the United Nations' Intergovernmental Panel on Climate Change as the basis for advocacy of green IT technology. Highlights green IT issues, particularly in terms of public opinion and governmental regulations. Recommends that companies develop cost-benefit analysis, then start by making data centers more environmentally friendly and energy efficient.

Velte, T., Velte, A., & Elsenpeter, R. (2008). *Green IT: Reduce your information system's environmental impact while adding to the bottom line*. New York: McGraw-Hill.

> Presents roadmap, strategies, justifications and plans for technology and processes used to upgrade information technology infrastructure to more environmentally-friendly components. Includes case studies from major IT organizations.

Visweswaraiah, D. (2010, September). Green IT - No longer a prerogative. *Communications Today*. Retrieved September 22, 2010, from http://www.communicationstoday.co.in/oct2007/green-it--no-longer-a-prerogative-3019-41.html.

> Discusses key green initiatives, and their benefits, from the perspective of an executive of one of the world's largest suppliers of information infrastructure systems, software and services. Highlights green IT trends, and gives some quick tips for successful strategies.