Harnessing Green IT: Principles and Practices

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Adopting a holistic approach to greening IT is our responsibility toward creating a more sustaining environment.

Enterprises, governments, and societies at large have a new important agenda: tackling environmental issues and adopting environmentally sound practices. Over the years, the use of IT has exploded in several areas, improving our lives and work and offering convenience along with several other benefits.

We are passionate about advances in and widespread adoption of IT. However, IT has been contributing to environmental problems, which most people don't realize. Computers and other IT infrastructure consume significant amounts of electricity, placing a heavy burden on our electric grids and contributing to greenhouse gas emissions. Additionally, IT hardware poses severe environmental problems both during its production and its disposal. IT is a significant and growing part of the environmental problems we face today. We are obliged to minimize or eliminate where possible the environmental impact of IT to help create a more sustainable environment.

To reduce IT's environmental problems and to create a sustainable environment, we call upon the IT sector as well as every computer user to *green* their IT systems, as well as the way they use these systems. We are legally, ethically, and socially required to green our IT products, applications, services, and practices. Green IT benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging

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reuse and recycling. Factors such as environmental legislation, the rising cost of waste disposal, corporate images, and public perception give further impetus to the green IT initiative.

Green IT is a hot topic today and will continue to be an important issue for several years to come. To foster green IT, we should understand: What are the key environmental impacts arising from IT? What are the major environmental IT issues that we must address? How can we make our IT infrastructure, products, services, operations, applications, and practices environmentally sound? What are the regulations or standards with which we need to comply? How can IT assist businesses and society at large in their efforts to improve our environmental sustainability?

In this article, we address these questions and examine related issues. We then present a holistic approach to greening IT. Additionally, we propose a green IT strategy for enterprises and outline specific ways to minimize IT's environmental impact.

Environmental Issues and Problems

The growing accumulation of greenhouse gases is changing the world's climate and weather patterns, creating droughts in some countries and floods in others. It's slowly pushing global temperatures higher, posing serious problems to the world (see http://egj.lib.uidaho.edu/index.php/egj/article/view/3205/3175). For instance, 2005 was the warmest year on record, and the 10 warmest years have all occurred since 1980. Global data shows that storms, droughts, and other weather-related disasters are growing more severe and more frequent.

To stop the accumulation of greenhouse gases in the atmosphere, global emissions would have to stop growing. Electricity is a major cause of climate change, because the coal or oil that helps generate electricity also releases carbon dioxide, pollutants, and sulfur into the atmosphere. These emissions can cause respiratory disease, smog, acid rain, and global climate change. Reducing electric power consumption is a key to reducing carbon dioxide emissions and their impact on our environment and global warming.

With this in mind, let's focus on what each of us—as IT professionals, members of the IT industry, and IT users—can do individually and collectively to create a sustainable environment. Let's examine IT's environmental impact and consider green IT measures that we can adopt.

IT's environmental impact

IT affects our environment in several different ways. Each stage of a computer's life, from its production, throughout its use, and into its disposal, presents environmental problems.

Manufacturing computers and their various electronic and non-electronic components consumes electricity, raw materials, chemicals, and water, and generates hazardous waste. All these directly or indirectly increase carbon dioxide emissions and impact the environment.

Each PC in use generates about a ton of carbon dioxide every year.

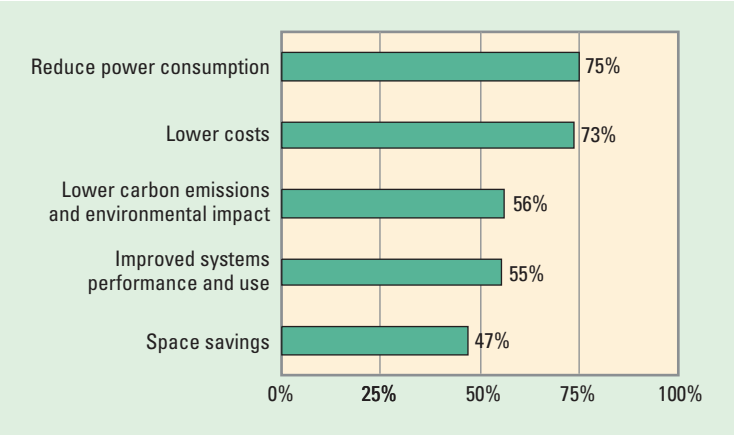
The total electrical energy consumption by servers, computers, monitors, data communications equipment, and cooling systems for data centers is steadily increasing. This increase in energy consumption results in increased greenhouse gas emissions. Each PC in use generates about a ton of carbon dioxide every year.

Computer components contain toxic materials. Increasingly, consumers discard a large number of old computers, monitors, and other electronic equipment two to three years after purchase, and most of this ends up in landfills, polluting the earth and contaminating water.

The increased number of computers and their use, along with their frequent replacements, make the environmental impact of IT a major concern. Consequently, there is increasing pressure on us—the IT industry, businesses, and individuals—to make IT environmentally friendly throughout its lifecycle, from birth to death to rebirth. As many believe, it's our social and corporate responsibility to safeguard our environment.

Green IT

Green IT refers to environmentally sound IT. It's the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as



1 **Reasons and benefits for using green IT practices.**

monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities.

Thus, green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling.

Green IT spans a number of focus areas and activities, including

- design for environmental sustainability;
- energy-efficient computing;
- power management;
- data center design, layout, and location;
- server virtualization;
- responsible disposal and recycling;
- regulatory compliance;
- green metrics, assessment tools, and methodology;
- environment-related risk mitigation;
- use of renewable energy sources; and
- eco-labeling of IT products.

A growing number of IT vendors and users are moving toward green IT and thereby assisting in building a green society and economy. When consumers are faced with more green taxes and regulations, they will favor green IT solutions. However, to build a greener environment, we must modify or abolish many old and familiar ways of doing things and discover new methods. Fortunately, the IT industry is interested in handling IT's environmental issues and pursuing new opportunities. Innovations in environmentally sustainable IT is the key to future success.

Benefits of greening IT

Environmental issues impact IT business' competitive landscape in new ways, and enterprises with the technology and vision to provide products and services that address environmental issues will enjoy a competitive edge. For example, when making purchasing, leasing, or outsourcing decisions, many customers now consider the service providers' environmental records and initiatives. Businesses face higher energy costs, and they may also incur additional government levies if they don't address the environmental implications of their practices. Investors and consumers are beginning to demand more disclosures from companies with regard to their carbon footprint as well as their environmental initiatives and achievements, and they have started discounting share prices of companies that poorly address the environmental problems they create. As a result, many businesses have begun showing their environmental credentials. For instance, the Carbon Disclosure Project (www.cdproject.net) is a recent initiative to petition global companies to disclose their carbon emissions.

Adopting green IT practices offers businesses and individuals financial and other benefits. IT operations achieve better energy efficiency through green initiatives, which financially benefit them, especially when electrical energy is at a premium and energy prices are rising. In a survey by Sun Microsystems Australia (see http://au.sun.com/edge/2007-07/eco.jsp?cid=920710) involving 1,500 responses from 758 large and small organizations in Australia and New Zealand, respondents said reducing power consumption and lowering costs are the major reasons for using eco-responsible practices, followed by a lower environmental impact and improved system use (see Figure 1).

Most companies are bound to prioritize environmental issues for environmental, energy-efficiency, and cost-control imperatives. As concerns, regulations, and market-based mechanisms to address climate change rise, businesses will focus on environmental sustainability. Corporate and institutional buyers are asking their suppliers to take

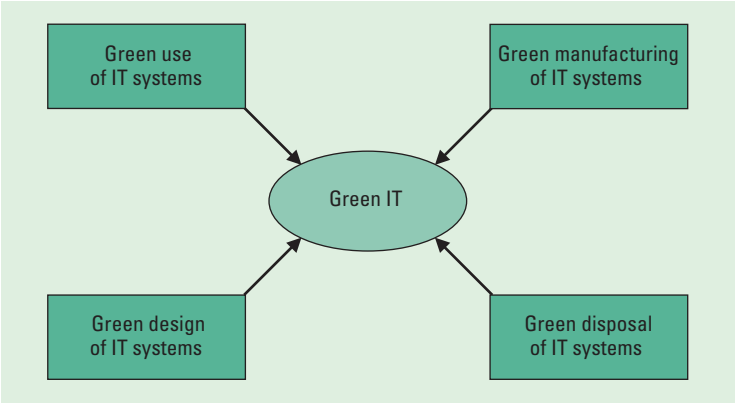
measures to "green up" their products and their manufacturing processes. For instance, companies such as Dell and Wal-Mart are adopting initiatives that force their suppliers to adhere to environmentally sound practices.

People have begun to value the environmentally friendly attributes of IT, and in the next five years, green IT will become a common feature. Companies will offer a range of new green products and services, and new business opportunities will emerge.

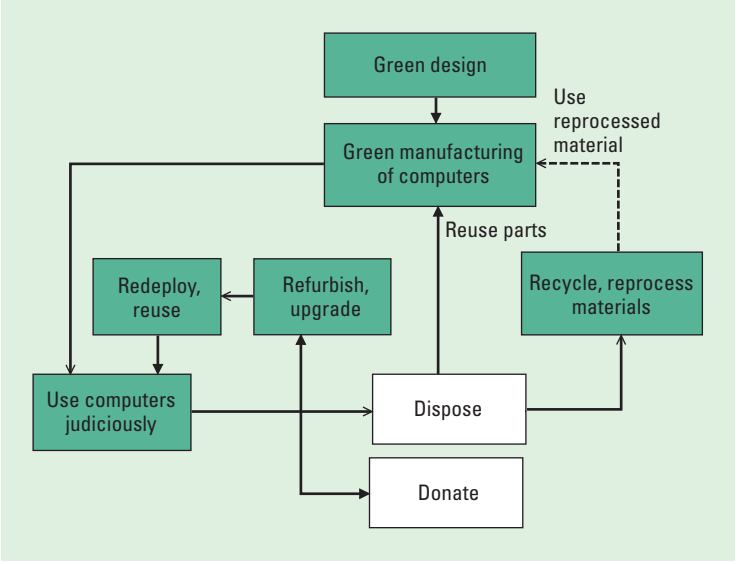
A Holistic Approach to Green IT

To comprehensively and effectively address the environmental impacts of IT, we must adopt a holistic approach that addresses the problems along the following four complementary paths (see Figure 2):

- *Green use.* Reduce the energy consumption of computers and other information systems and use them in an environmentally sound manner.
- *Green disposal.* Refurbish and reuse old computers and properly recycle unwanted computers and other electronic equipment.
- *Green design.* Design energy efficient and environmentally sound components, computers, servers, and cooling equipment.
- *Green manufacturing.* Manufacture electronic components, computers, and other associated subsystems with minimal or no impact on the environment.



2 Holistic approach to green IT.



3 Green a computer's entire lifecycle.

By focusing our efforts on these four fronts, we can achieve total environmental sustainability from the IT side and make IT greener throughout its entire lifecycle (see Figure 3).[1] Next, let's explore these measures.

Using IT: Environmentally Sound Practices

A key green objective in using computer systems and operating data centers is to reduce their energy consumption, thereby minimizing the greenhouse gas emissions.

Reducing energy consumption by PCs

We can significantly reduce energy consumption by making small changes to the ways we use computers. Most personal desktop computers run even when they aren't being used, because users needlessly leave them on, wasting electricity. Furthermore, computers generate heat and require additional cooling, which adds to the total power consumption and cost for the enterprise. While the savings in energy costs per PC may not seem like much, the combined savings for hundreds of computers in an enterprise is considerable. We can reduce PC energy consumption by adopting several measures.

Enabling power management features. Without sacrificing performance, we can program computers to automatically power down to an energy-saving state when we aren't using them. The US Environmental Protection Agency (EPA) estimated that providing computers with a sleep mode reduces their energy use by

60–70 percent (see http://ecenter.colorado.edu/energy/projects/green_computing.html).

Because PC use is widespread across any given organization, it's difficult for the IT staff to manage their enterprise's PC power consumption. In this case, a pragmatic approach is to use software such as Surveyor from Verdiem (www.verdiem.com) that offers network-level control over PCs and monitors. The software places the PC into a lower-power consumption mode, such as shutdown, hibernation, or standby, and monitors into a sleep mode when they aren't being used. It also measures and reports how much power each PC and monitor consumes. Network managers can remotely awake the PCs for software upgrades, maintenance, or backup.

Turning off the system when not in use. This is the most basic energy conservation strategy for most systems. Many people believe the misconception that a computer's life is shortened by turning it on and off, so they leave their computers on all the time. The electronic equipment's life span depends on its cumulative operational time and its temperature. Turning it off reduces both of these factors, increasing the life of the equipment. Manufacturers protect personal computers' internal circuitry from power damage from on/off switching, and they design modern hard drives to operate reliably for thousands of on/off cycles. Therefore, users actually benefit from turning off their systems when they aren't using them.

Some people are reluctant to switch their computers on and off a couple of times during their workday, because they don't want to wait a minute or two until the system is ready for use. However, the energy savings are well worth the inconvenience of waiting a short time for a computer to reboot or a peripheral to come online.

Using screensavers. A blank screensaver conserves more power than a screensaver that displays moving images, which continually interacts with the CPU. But even that reduces the monitor's energy consumption by only a small percentage.

Using thin-client computers. Users can choose to employ thin-client computers, which draw about a fifth of the power of a desktop PC.

These measures, though easily adoptable, wouldn't become a practical reality without users' wholehearted willingness and active participation. To make these efforts a success, enterprises must educate their employees to save energy by changing their computer habits. Enterprises must seek their employees' feedback, address their concerns, and encourage them to join in green computing efforts.

Greening data centers

The continued rise of Internet and Web applications is driving the rapid growth of data centers. Enterprises are installing more servers or expanding their capacity. The number of server computers in data centers has increased sixfold to 30 million in the last decade, and each server draws far more electricity than earlier models. Aggregate electricity use for servers doubled between 2000 and 2005, most of which came from businesses installing large numbers of new servers.[2] With energy prices increasing worldwide, the operational cost of data centers continues to increase steadily. Besides the cost, availability of electrical power is becoming a critical issue for many companies whose data centers have expanded steadily. The social, financial, and practical constraints involved will force businesses and IT departments to reduce energy consumption by data centers.

We can improve data center efficiency by using new energy-efficient equipment, improving airflow management to reduce cooling requirements, investing in energy management software, and adopting environmentally friendly designs for data centers and new measures to curb data centers' energy consumption. According to a recent purchasing survey (see http://searchdatacenter.techtarget.com/originalContent/0,289142,sid80_gci1264212,00.html):

- more than 50 percent of data center professionals who responded to the survey said they have saved energy through server virtualization;
- 32 percent have made efforts to improve underfloor air-conditioning efficiency;
- 17.5 percent have implemented power-down features on servers not in use;

- 11 percent have tried DC power in the data center; and
- only 7.7 percent have tried liquid cooling for increased data center cooling efficiency.

Though liquid is several hundred times more efficient than air for cooling hot servers, customers are nonetheless unwilling to use liquid cooling, perhaps because of the complexities involved with it. However, if the high-density computing infrastructure requires liquid cooling, data center managers may have to adapt to it and deal with the complexities involved.

In a survey by Sun Microsystems Australia, 80 percent of respondents said they would use energy-efficient technologies, 63 percent said they would use power and cooling solutions, and 60 percent said they would use system virtualization (see http://au.sun.com/edge/2007-07/eco.jsp?cid=920710).

In the following paragraphs, we outline three broad measures to greening data centers: energy conservation, eco-friendly design, and server virtualization.

Energy conservation. Energy costs now account for nearly 30 percent of a data center's operating expenses (see http:/news.zdnet.co.uk/itmanagement/0,1000000308,39284324,00.htm), a significant amount of which is spent on cooling. The IT industry is inventing new ways to help address this issue. For example, companies like IBM, Hewlett Packard, SprayCool, and Cooligy are working on technologies such as liquid cooling, nano fluid-cooling systems, and in-server, in-rack, and in-row cooling. Other innovative ways of making a data center more environmentally friendly include using new high-density servers, using hydrogen fuel cells as alternative green power sources, and applying virtualization technologies that reduce the total power consumption of servers and lower the heat generated.

Old mainframe computers are bulky power hogs that demand a lot of cooling. Hence, major IT vendors are addressing these problems by assisting their customers in migrating applications from mainframes to servers.

Eco-friendly design. Eco-friendly data center designs use a synthetic white rubber roof, paint, and carpet that contain a low volatile organic compound (VOC), countertops made of recycled products, and energy-efficient mechanical and electrical systems at optimal efficiency. Eco-designs make use of natural light as well as green power—electricity generated from solar or wind energy—to run the data center. Enterprises that adopt eco-friendly designs can get tax incentives and gain a competitive advantage, as more and more customers want to work with eco-friendly firms.

While building a new data center provides complete design control, IT professionals can take measures to reduce heat, add light, and discard materials that contain toxic chemicals in existing data centers. For instance, they can use energy-efficient windows, skylights, and skytubes, and change the paint and carpet to a low-VOC variety.

Many American enterprises are adopting the Leadership in Energy and Environmental Design (LEED) standards maintained by the US Green Building Council (www.usgbc.org) for building new data centers. LEED promotes a "whole-building approach" to sustainability, focusing on five key areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

Virtualization. Virtualization is a key strategy to reduce data center power consumption (see www.infoworld.com/archives/t.jsp?N=s&V=85855). With virtualization, one physical server hosts multiple virtual servers. Virtualization enables data centers to consolidate their physical server infrastructure by hosting multiple virtual servers on a smaller number of more powerful servers, using less electricity and simplifying the data center. Besides getting better hardware usage, virtualization reduces data center floor space, makes better use of computing power, and reduces the data center's energy demands. Many enterprises are using virtualization to curb the runaway energy consumption of data centers.

To tackle the issue of data centers' huge power consumption, leading IT enterprises joined forces in February 2007, to form a nonprofit group called the Green Grid (www.thegreengrid.org). This group seeks to define and propagate the best energy-efficient practices in data center operation, construction, and design, and drive new user-centric metrics and technology

Greening Unwanted Computers: The Three Rs

Unwanted computers and monitors shouldn't be thrown away in rubbish bins, as they will then end up in landfills causing serious environmental problems. Instead, we should refurbish and reuse or recycle them in environmentally sound ways. Here we outline how you can do that.

Reuse

Why do we need to buy new computers for each and every project or once every two or three years? We should make use of an older computer if it meets our requirements. Otherwise, we should give it to someone who needs it or use functional components from a retired product. By using the hardware for a longer period of time, we can reduce the total environmental footprint caused by computer manufacturing and disposal.

Refurbish

We can refurbish and upgrade old computers and servers to meet new requirements. We can make an old computer and other IT hardware almost new again by reconditioning and replacing their parts. Rather than buying a new computer to our specifications, we can buy refurbished IT hardware in the market. More enterprises are open to purchasing refurbished goods, and the market for refurbished IT equipment is growing.

From the green angle, reusing what we have is a better long-term way of managing resources. Fiscally speaking, we can potentially save our cash flow, and capital expenditures. If these options are unsuitable, we can donate the equipment to charities or schools or trade in our computers. Charities refurbish old computers and give them to those in need.

Recycle

When we can't reuse computers, even after considering the prospects of refurbishing, we must dispose of them properly in environmentally friendly ways. Most unwanted computers and electronic goods end up in landfills. Electronic waste or e-waste—discarded computers and electronic goods—is one of the fastest-growing waste types, and the problem of e-waste is global. Analysts predict that two-thirds of the estimated 870 million PCs made worldwide in the next five years will end up in landfills. The United Nations Environment Program (www.unep.org) estimates that 20 to 50 million tons of e-waste are generated worldwide each year, and this is increasing (see www.unep.org/Documents.Multilingual/Default.asp?DocumentID=485& ArticleID=5431&l=en).

Computer components contain toxic materials like lead, chromium, cadmium, and mercury. If we bury computers in landfills, toxic materials can leach harmful chemicals into waterways and the environment. If burned, they release toxic gases into the air we breathe, so if e-waste is not discarded properly, it can harm the environment and people. In addition, e-waste can be a valuable source for secondary raw materials. We should recycle old electronic systems by taking component material and reprocessing it into the same material or breaking it down into constituent materials for reuse.

The Waste Electrical and Electronic Equipment regulations (WEEE; see www.netregs.gov.uk/netregs/legislation/380525/473094/?lang=e) aim to reduce the amount of e-waste going to landfills and to increase recovery and recycling rates. The WEEE regulations deal with the following major areas:

- separate collection, disposal, and recycling;
- standards for e-waste treatment at authorized facilities; and
- collection, recycling, and recovery targets.

Electrical and electronic manufacturers can also apply WEEE regulations.

standards (for details, see the white papers at www.thegreengrid.org/gg_content).

No More "Out with the Old"

We shouldn't throw away old computers, monitors, and other IT hardware anymore, as they can cause serious environmental problems. We should try to give life to them in environmentally sound ways by reusing, refurbishing, or recycling them. For details see the sidebar, "Greening Unwanted Computers: The Three Rs."

Designing Green Computers

Green computer design aims to reduce the environmental impact of computers by adopting new technologies and using new techniques and materials while balancing environmental compatibility with economic viability and performance. Green design is quickly becoming a necessary business practice. Many computer manufacturers are in the process of making green PCs using nontoxic materials that consume less electrical power and are easily reassembled.

These new computers are highly upgradable, thereby extending their useful lifetime.

The move from single-core to dual- and quad-core processors saves power while increasing processing performance. This contrasts the old method of improving performance of microprocessors by increasing the frequency of the chip's operation, which hugely increases power consumption and heat generation. A 15-percent reduction in frequency could save up to 50-percent power consumption.

Other initiatives, such as dividing the cache into segments that are only powered when required and moving to a 45-nanometer architecture, also reduces power consumption. Manufacturers now apply power-reduction techniques commonly used for laptops, such as screens that darken the backlight and lighten the display palette as well as flash memory caches for hard disks, desktops, and servers. On the data storage front, a smaller number of higher-capacity drives is up to 50 percent more energy efficient than the equivalent large number of small-capacity drives.

IT vendors are now investing significant resources in green initiatives such as developing energy-efficient servers, data center cooling solutions, and new materials and design options.

Recently, Dell, Apple, and other computer vendors announced their environmental strategy designed to make their computers green for the long term. Dell aims its new Zero Carbon Initiative at maximizing the energy efficiency of Dell products, and over time plans to offset its carbon impact. As a key aspect of this initiative, it requires that its suppliers publicly report their greenhouse gas emissions. Apple has said it will reduce or eliminate toxic chemicals present in its new products and more aggressively recycle its old products.

Companies have launched new tools, standards, and product registration to assist customers in assessing the environmental attributes of PCs, notebooks, servers, and other hardware. They include Epeat, the Energy Star 4.0 Standard, and the RoHS Directive. For details, see the sidebar "Green IT Standards and Regulations" on the next page.

Enterprise Green IT Strategy

Each enterprise must develop a holistic, comprehensive green IT strategy, which should be a component of, and aligned with, an overall enterprise-wide green strategy. It should then develop a green IT policy outlining aims, objectives, goals, plans of action, and schedules. Large enterprises should also appoint an environmental sustainability officer to implement their green policy and to monitor their progress and achievements.

To green their IT, enterprises can take any one or a combination of the following three approaches:[1]

- *Tactical incremental approach.* In this approach, an enterprise preserves the existing IT infrastructure and policies and incorporates simple measures to achieve their moderate green goals such as reducing energy consumption. These measures include adopting policies and practices such as power management, switching off computers when not in use, using compact energy-efficient light bulbs, and maintaining an optimal room temperature. These measures are generally easy to implement without much cost. However, enterprises should work toward these measures only as short-term, ad hoc solutions.
- *Strategic approach.* In this approach, an enterprise conducts an audit of its IT infrastructure and its use from an environmental perspective, develops a comprehensive plan addressing broader aspects of greening its IT, and implements distinctive new initiatives. For example, an enterprise may deploy new energy-efficient, environmentally friendly computing systems, or it may develop and implement new policies on procurement, operation, and/or disposal of computing resources. While the primary rationale is still cost efficiency and a reduced carbon footprint, it also considers other factors such as branding, image creation, and marketing.
- *Deep green approach.* This approach expands upon the measures highlighted in the strategic approach, wherein an enterprise adopts additional measures such as implementing a carbon offset policy to neutralize greenhouse gas emissions—including planting trees, buying carbon credits from one of many carbon exchanges, or using green power generated from solar or wind energy.

Green IT Standards and Regulations

Green IT standards and regulations, Epeat (www.epeat.net), the Energy Star 4.0 standard, and the RoHS Directive (www.rhos.gov.uk) can help you design green computers and other IT hardware and classify them based on their environmental attributes.

Epeat

Prompted by the need for an evaluation tool that allows the selection of electronic products based on environmental performance, the Green Electronics Council (www.greenelectronicscouncil.org) has launched the Electronic Product Environmental Assessment Tool (Epeat; see www.epeat.net). Epeat assists buyers to evaluate, compare, and select desktop computers, notebooks, and monitors based on their environmental attributes. It also helps manufacturers promote their products as environmentally sound.

Epeat evaluates electronic products on 23 required criteria and 28 optional criteria, which are grouped into eight performance categories (see www.greenelectronicscouncil.org/epeat/criteria.htm): reducing and eliminating environmentally sensitive materials, selecting materials, designing for the product's end of life (such as recycling), product longevity, energy conservation, end-of-life management, corporate performance, and packaging.

Epeat identifies its registered products as bronze, silver, or gold. Bronze products meet all 23 required criteria. Silver products meet all 23 required criteria plus at least 14 optional criteria, and gold products meet all 23 required criteria plus at least 21 optional criteria. Manufacturers can pick and choose among the optional criteria to boost their Epeat score to achieve a higher level of registration.

All Epeat-registered computers have reduced levels of cadmium, lead, and mercury to better protect human health. These are more energy-efficient and easier to upgrade and recycle. In fact, manufacturers of Epeat products must offer safe recycling options for the products when they're no longer usable.

Epeat recognizes several desktop computers, laptops, and monitors from leading manufacturers as green products (www.epeat.net/Search.aspx). Some computer contracts issued by major government agencies in the US as well as some private enterprises already reference Epeat.

Energy Star 4.0 Standard

The new Energy Star 4.0 standard regulates energy performance of external and internal power supplies and gives power consumption specifications for idle, sleep, and standby modes for a number of different devices including PCs, desktops, and gaming consoles. Computers meeting the new requirements will save energy in all modes of operation. Regulations for computers in idle mode are new, as previous standards addressed only sleep and standby modes. The new specifications require OEMs to educate users about power management.

RoHS Directive

The Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive (RoHS; see www.rohs.gov.uk and www.netregs.gov.uk/netregs/275207/1628456/?lang=_e) aims to restrict the use of certain hazardous substances. It also bans placing new electrical and electronic equipment on the European Union market if it contains more than the agreed-upon levels of lead, cadmium, mercury, hexavalent chromium, or flame retardants.

An enterprise may also encourage its employees to go green with their home computers by offering incentives such as planting a tree, buying carbon credits, supplying them with free power management software, and offering computer recycling/trade-in provisions.

Hopefully, in the beginning enterprises will adopt an incremental approach and then move progressively by implementing other initiatives to reach a full green IT status.

Using IT for Environmental Sustainability

Besides IT itself being green, it can support, assist, and leverage other environmental initiatives by offering innovative modeling, simulation, and decision support tools, such as

- software tools for analyzing, modeling, and simulating environmental impact, and environmental risk management;
- platforms for eco-management, emission trading, or ethical investing;
- tools for auditing and reporting energy consumption and savings and for monitoring greenhouse gas emissions;
- environmental knowledge management systems, including geographic informa-

tion systems and environmental metadata standards;
- urban environment planning tools and systems;
- technologies and standards for interoperable environmental monitoring networks and smart in situ sensors networks; and
- integrating and optimizing existing environmental monitoring networks and new easy plug-in sensors.

Using IT to Create Green Awareness

In addition to moving itself in a greener direction and leveraging other environmental initiatives, IT could help create green awareness among IT professionals, businesses, and the general public by assisting in building communities, engaging groups in participatory decisions, and supporting education and green advocacy campaigns. Along these lines, tools such as environmental Web portals, blogs, wikis, and interactive simulations of the environmental impact of an activity could offer assistance.

IT is part of the environmental problem, and it can be part of the solution. Green IT is an economic, as well as an environmental, imperative. Greening IT is and will continue to be a necessity, not an option. Green IT represents a dramatic change in priority in the IT industry. So far, the industry has been focusing on IT equipment processing power and associated equipment spending. It's not been concerned with other requirements such as power, cooling, and data center space. However, going forward, the IT industry will need to deal with all of the infrastructure requirements and the environmental impact of IT and its use.

The challenges of green IT are immense; however, recent developments indicate that the IT industry has the will and conviction to tackle our environmental issues head-on (see the "Green IT Resources" sidebar). Companies can benefit by taking these challenges as strategic opportunities. The IT sector and users must develop a positive attitude toward addressing environmental concerns and adopt forward-looking, green-friendly policies and practices. IT

Green IT Resources

The following are some helpful electronic resources:

- *CIO's* "Green IT" page (http://advice.cio.com/taxonomy/term/27/0) discusses how to stay out of the red with an environmental approach. It covers news, comments on new developments and initiatives, and offers opinions and advice.
- *InfoWorld's* "Sustainable IT" page (http://weblog.infoworld.com/sustainableit) tracks trends toward a greener, more energy-efficient IT.
- *Greener Computing* (www.greenercomputing.com) is a resource for environmentally friendly computers.
- The *Green Wombat* blog (http://blogs.business2.com/greenwombat) focuses on the environment and technology and covers energy efficiency, green computing, carbon credits, and other areas.
- The *Data Center Knowledge* newsletter (www.datacenterknowledge.com) presents news and analysis about data centers, managed hosting, and disaster recovery.
- *InfoWorld's Green Tech* newsletter (subscribe at http://subscribe.infoworld.com/cgi-win/ifwd.cgi?m=newsletter) presents how businesses are examining how they use their resources and exploring ways to save energy, materials, and money with green IT.
- *GreenBiz* (www.greenbiz.com) is the leading information resource on how to align environmental responsibility with business success.

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