International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)
Web Site: www.ijettcs.org Email: editor@ijettcs.org, editorijettcs@gmail.com
Volume 7, Issue 2, March - April 2018 ISSN 2278-6856

Green Computing: Efficient and Eco-friendly Use of Computer Resources to Improve Energy Utilization

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Abstract: ***Computers are widely used globally in business, industry, e-Agriculture, bioinformatics, medical and environmental sciences, and in every organization. Their immense application and usage requires huge amount of electricity and always lead to higher operational cost of the system. The utilization of electrical energy during working of computers generates heat as per the thermodynamics rules and therefore, air conditioners are used for providing cooling environment during working of computers and servers. Moreover, the emission of greenhouse gases such as carbon dioxide along with heat generation leads to depletion of ozone layer resulting in global warming that cause various harmful impacts on our environment and natural resources. In modern era of technology, it is also not possible to avoid the usage of computers in increasingly competitive world. Therefore, an alternative eco-friendly and cost effective technology is required in order to reduce the negative impact of computing technology on our natural resources. Green computing has emerged as eco-friendly technology for the use of computers, peripherals and servers to minimize the carbon footprint and effective use of energy. In this paper, several green initiatives currently undertaken in the computer industry to maximize energy efficiency and e-waste recycling process have been discussed. Moreover, the effective implementation of Green Computing is highlighted by minimizing the wastage of energy in small, medium and large organizations, and to promote recyclability of industrial waste.***

Keywords: Green computing, Energy usage, Green house effect, Environment, Waste recycling, Cloud computing.

1. INTRODUCTION

Green computing is the study and practice of using computing resources efficiently. The goals are similar to green chemistry i.e., to reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime and promote recyclability or biodegradability of defunct products. Taking into consideration the popular use of information technology in industry, this “Green technology” should impress activists leading to concrete action and organizational policy. Various organizations are involved in finding green technology as a way to create new profit centers while trying to help the environmental cause. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy savings [1, 2].

Since most computers and communication systems have to run 24/7 in a cloud computing infrastructure, the energy consumption of a system is of great importance. For example, high energy consumption always leads to higher operational cost of the system. As the number of computers is increasing day by day, so is the amount of electricity consumed by them, which in turn is increasing the carbon content in the atmosphere. Moreover, high energy consumption leads to heat production and therefore more energy is required for cooling down the surrounding environment. This problem has been realized by the researchers and several corrective measures are being taken which help in minimizing the power usage of computers. For example, a user must set the power option in a computer in economic mode or the computer should go to sleep mode, when the user is not using the computer. When a user goes away from the computer for more than a few minutes, then the computer should go to stand-by mode or it may switch off automatically to use appreciable amount of energy. This paper presents several green initiatives currently under way in the computer industry, as well as issues that have been raised regarding these initiatives about the future of Green Computing.

2. HISTORY OF GREEN COMPUTING

The U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program in 1992, which is designed to promote and recognize energy-efficiency in monitors, climate control equipment and other technologies. This resulted in the widespread adoption of sleep mode among consumer electronics. The term "green computing" was probably coined shortly after the Energy Star program began [3]. Governments of several countries worldwide have initiated energy-management programs, such as Energy Star to reduce the amount of energy consumed by a product by automatically switching it into sleep mode when not in use or reducing the amount of power used by a product when in standby mode.

Energy-intensive manufacturing of computer parts can be minimized by making manufacturing process more energy efficient by replacing petroleum-filled plastic with bioplastics. Plant-based polymers require less oil and energy to produce than traditional plastics with a challenge to keep these bioplastic computers cool so that electronics won't melt them. Power-sucking displays can be replaced with green light displays made of OLEDs, or organic light-emitting diodes. Future computers could knock 10% off their energy use just by replacing hard drives with solid-

state or flash, memory, which has no watt-hungry moving parts.

There are several organizations providing certificates to green technology. Vendors are based on their product quality, material, life of the product and recycling capabilities. In future such certifications together with recommendations and government regulations will put more pressure on vendors to use green technology and reduce impact on environment.

3. COMPANIES USING GREEN COMPUTING TECHNOLOGY

Many companies have started manufacturing environmentally friendly products using a range of clean-computing strategies. The major companies following green computing protocols are described in this section.

3.1. VIA Technologies: It is a Taiwanese company that manufactures motherboard chipsets, CPUs, and other computer hardware, introduced its initiative for "green computing" in 2001. With this green vision, the company has been focusing on power efficiency throughout the design and manufacturing process of its products. Its environment-friendly products are manufactured using a range of clean-computing strategies and the company is striving to educate markets on the benefits of green computing for the sake of the environment as well as productivity and overall user experience.

3.1.1. Carbon-free computing

One of the goals of VIA Technologies is to reduce the "carbon footprint" of users, the amount of greenhouse gases produced, measured in units of carbon dioxide (CO_2). Green house gases naturally blanket the Earth and are responsible for its more or less stable temperature. An increase in the concentration of the main greenhouse gases i.e., carbon dioxide, methane, nitrous oxide and fluorocarbons, is believed to be responsible for Earth's increasing temperature, which could lead to severe floods and droughts, rising sea levels, and other environmental effects, affecting both life and the world's economy [4]. VIA aims to offer the world's first PC products certified carbon free, taking responsibility for the amounts of CO_2 they emit.

Another goal of VIA's green-computing initiative is the development of energy-efficient platforms for low-power, small-form-factor (SFF) computing devices. The company works with environmental experts to calculate the electricity used by the device over its lifetime, generally three years. From this data, one can conclude how much carbon dioxide the device will emit into the atmosphere during its operation. This estimate will serve as an indicator and the company will pay regional organizations for the offsetting of the emissions. This offsetting of carbon dioxide can be achieved in different ways:

(i) One way is to plant trees that absorb CO_2 as they grow, in the region in which the processors were purchased. The necessary amount of trees per processor is represented by VIA's TreeMark rating system.

(ii) VIA promotes the use of alternative energy sources such as solar power, so that power plants wouldn't need to burn as much fossil fuels, thereby reducing the amount of energy used.

(iii) Wetlands also provide a great service in sequestering some of the carbon dioxide emitted into the atmosphere. Although they make up only 4 to 6% of the Earth's landmass, wetlands are capable of absorbing 20 to 25% of the atmospheric carbon dioxide. VIA is working closely with organizations responsible for preserving wetlands and other natural habitats and others who support extensive recycling programs for ICT equipment. The amount paid to these organizations will be represented by a proportion of the carbon-free product's price.

(iv) In 2005, the company introduced the VIA C7-M and VIA C7 processors that have a maximum power consumption of 20 watts (W) at 2.0 GHz and an average power consumption of one watt. These energy-efficient processors produce over four times less carbon during their operation and can be efficiently embedded in solar-powered devices [5].

3.2. Dell company: Carbon emissions control has been a key issue for many companies who have expressed a firm commitment to sustainability. Dell is a good example of a company with a green image, known for its free worldwide product-recycling program. Dell's Plant a Tree for Me project allows customers to offset their carbon emissions by paying an extra $ 2 to $ 4, depending on the product purchased.

3.3. AMD: A global microprocessor manufacturer is also working toward reducing energy consumption in its products, cutting back on hazardous waste and reducing its eco-impact. The company's use of silicon-on-insulator (SOI) technology in its manufacturing and strained silicon capping films on transistors (known as - dual stress liner technology), have contributed to reduced power consumption in its products.

3.4. Intel: The world's largest semiconductor maker, uses virtualization software, a technique that enables Intel to combine several physical systems into a virtual machine that runs on a single, powerful base system, thus significantly reducing power consumption.

Intel has also joined Google, Microsoft and other companies in the launch of the Climate Savers Computing Initiative that commits businesses to meet the Environmental Protection Agency's Energy Star guidelines for energy-efficient devices.

3.5. Google Inc: With the aid of a self-styled ultra-efficient evaporative cooling technology, Google Inc. has been able to reduce its energy consumption to 50% of that of the industry average.

3.6. Advanced Power Management: It is a joint venture of Intel and Microsoft that allows a computer's BIOS to control power management functions in a computer.

4. STEPS FOR ADOPTION OF GREEN COMPUTING

The adoption of the following strategies will strengthen the concept and policy of green computing.

4.1. Develop a sustainable green computing plan

Discuss with the business leaders the elements that should be factored into such a plan, including organizational policies and checklists. Such a plan should include recycling policies, recommendations for disposal of used equipment, government guidelines and recommendations for purchasing green computer equipment. Green computing best practices and policies should cover power usage, reduction of paper consumption as well as recommendations for new equipment and recycling of old machines.

4.2. Recycling of outdated computers

Discard used or unwanted electronic equipment in a convenient and environmentally responsible manner. Computers have toxic metals and pollutants that can emit harmful emissions into the environment [6]. Never discard computers in a landfill. Recycle them instead through manufacturer programs such as HP's Planet Partners recycling service or recycling facilities in your community or donate still-working computers to a non-profit agency.

4.3. Make environmentally sound purchase decisions

While buying a monitor, one should keep in mind one's requirements as a 17-inch monitor uses 40% more energy than a 14-inch monitor. Also, the higher the resolution, the more energy it needs. Ink-jet printers, though a little slower than laser printers, use 80 to 90% percent less energy. Thus, choice should be made wisely.

Consumers should purchase Electronic Product Environmental Assessment Tool (EPEAT) registered products. EPEAT is a procurement tool promoted by the nonprofit Green Electronics Council to help institutional purchasers evaluate, compare and select desktop computers, notebooks and monitors based on environmental attributes. It provides a clear, consistent set of performance criteria for the design of products. EPEAT recognizes manufacturer efforts to reduce the environmental impact of products by reducing or eliminating environmentally sensitive materials, designing for longevity and reducing packaging materials

4.4. Reduce paper consumption

There are many easy ways to reduce paper consumption: e-mail, electronic archiving, use the track changes feature in electronic documents, rather than redline corrections on paper. For taking print of documents, make sure to use both sides of the paper, recycle regularly, use smaller fonts and margins, and selectively print required pages.

4.5. Conserve energy

Turn off your computer when you are not going to use it for an extended period of time. Turn on power management features during shorter periods of inactivity. Power management allows monitors and computers to enter low-power states when sitting idle. Turn off the computer when the period of inactivity is more. The computer or monitor awakens from its low power sleep mode in seconds by simply hitting the keyboard or moving the mouse. Power management tactics can save energy and help protect the environment. Activating the power management features on your computer saves energy and money while helping the environment. Computer's Sleep and Hibernate settings are two of the most effective ways to make computer more environment-friendly.

- **Sleep mode:** It allows the monitor to fall asleep after idling for some time period is another easily employed method for improving energy efficiency. When a monitor falls asleep or enters a "stand by" mode, it enters a low power consumption state [7]. It saves 60-70% of electricity. The monitor screen will be blank, with no light emitting from it.
- **Hibernate mode:** The hibernate mode goes one step further than standby mode by completely powering off the computer. Invoking the hibernate mode causes the memory state to be saved onto the hard disk before powering down. When coming out of hibernate mode, the computer restores the memory state, returning the computer to its pre-hibernate state. A desktop computer will consume approximately 3 watts in hibernate mode vs 5 watts for standby. A disadvantage of the hibernate mode is that it takes slightly longer to enter and exit hibernate than standby, the result of saving and restoring the memory state to and from the disk.
- **Screen savers:** One of the simplest and most familiar power saving methods is the proper use of screen savers. The typical graphical screen saver, originally designed to minimize "burn-in" of computer monitors, actually increases power consumption rather than using a 3D graphics screen saver, and with screen burn-in no longer a concern, power use easily can be reduced by disabling screen savers. In this way, power consumed by intensive graphics is eliminated, leading to the monitor "falling asleep" after a period of idling, automatically conserving still more power. Therefore, switch off the computer and restart it again as and when required.
- **System Standby mode:** Standby is a mode the computer, monitor, or other device enters when idle for too long. This mode helps conserve power when a computer or computer device is not in use without having to sacrifice the time it would take to turn off and on the computer. When in standby, the computer or monitor has a solid of flashing light, indicating that there is still power but the computer is in Standby. To resume, wake, or wake up a computer in Standby mode move the mouse, press a key on the keyboard, or press the power button on the computer without holding it down for more than a few seconds.

4.6. Other techniques to improve energy efficiency

Organic light-emitting diodes should be used instead of the regular monitors. The manufacturing of disks and boxes needed for video games takes up a lot of resources. Video game manufacturers can offer their games online for download, leading to reduction in e-waste. This move can

also cut down on the transportation/shipping cost. Data centers can potentially improve their energy and space efficiency through techniques such as storage consolidation and virtualization. Under-volting is a process in which both the amount of heat and electricity consumed is managed manually by the user by adjusting voltage supplied to the user [8]. SpeedStep technology can also be put to practice to automatically manage the power consumption of a computer.

5. APPROACHES TO IMPLEMENT GREEN COMPUTING

Following approaches are helpful in implementation the concept of green computing. These various approaches include virtualization, power management, power supply, storage, displays, materials recycling, telecommuting, cloud computing and data compression.

5.1. Virtualization

Computer virtualization is the process of running two or more logical computer systems on one set of physical hardware. One of the primary goals of almost all forms of virtualization is making the most efficient use of available system resources. With energy and power costs increasing as the size of information technology (IT) infrastructures grow, holding expenses to a minimum is quickly becoming a top priority for many IT organizations. Virtualization has helped in that respect by allowing organizations to consolidate their servers onto fewer pieces of hardware, which can result in sizable cost savings. The data center is where virtualization can have the greatest impact and there where many of the largest companies in the virtualization space are investing their resources.

The concept originated with the IBM mainframe operating systems of the 1960s, but was commercialized for x86-compatible computers only in the 1990s. With virtualization, a system administrator could combine several physical systems into virtual machines on one single, powerful system, thereby unplugging the original hardware and reducing power and cooling consumption [9]. Several commercial companies and open-source projects now offer software packages to enable a transition to virtual computing. Intel corporation and AMD have also built proprietary virtualization enhancements to the x86 instruction set into each of their CPU product lines, in order to facilitate virtualized computing.

Virtualization also fits in with the idea of “Green Computing”; by consolidating servers and maximizing CPU processing power on other servers, you are cutting costs (saving money) and taking less of a toll on our environment. Storage virtualization uses hardware and software to break the link between an application, application component, system service or whole stack of software and the storage subsystem. This allows the storage to be located just about anywhere, on just about any type of device, replicated for performance reasons, replicated for reliability reasons or for any combination of the above.

In the past, it was necessary for each computer system to have its own storage to function. Storage virtualization makes it possible for systems to access a shared storage subsystem. It also means that copies of data that are used to be stored on every computer’s disks can now be stored once in the shared storage subsystem. It’s clear that this approach would reduce the number of storage devices needed, the amount of power required, the heat produced and would reduce the operational and administrative costs of back up, archival storage. Since the link between the application and the actual storage device is broken by storage virtualization software, the device can be selected based upon what’s most appropriate. Applications and data that are accessed frequently can be stored on high speed, expensive devices that consume more power. Applications and data that are accessed less frequently can be stored on lower speed, less expensive devices that consume less power. Rarely accessed applications and data can be migrated to archival storage devices that result in the lowest cost and require the lowest power consumption.

5.2. Power management

Power management for computer systems are desired for many reasons, particularly, (i) to prolong battery life for portable and embedded systems, (ii) reduce cooling requirements, (iii) reduce noise, and (iv) to reduce operating costs for energy and cooling. Moreover, lower power consumption also means lower heat dissipation, which increases system stability and less energy use, which saves money and reduces the impact on the environment [10].

- The Advanced Configuration and Power Interface (ACPI), an open industry standard, allows an operating system to directly control the power saving aspects of its underlying hardware. This allows a system to automatically turn off components such as monitors and hard drives after set periods of inactivity. In addition, a system may hibernate, where most components (including the CPU and the system RAM) are turned off. ACPI is a successor to an earlier Intel-Microsoft standard called Advanced Power Management, which allows a computer's BIOS to control power management functions.
- Some programs allow the user to manually adjust the voltages supplied to the CPU, which reduces both the amount of heat produced and electricity consumed. This process is called under-volting. Some CPUs can automatically under-volt the processor depending on the workload; this technology is called "SpeedStep" on Intel processors, "PowerNow!"/"Cool'n'Quiet" on AMD chips, LongHaul on VIA CPUs, and LongRun with Transmeta processors.

The power management for microprocessors can be done over the whole processor, or in specific areas. With dynamic voltage scaling and dynamic frequency scaling, the CPU core voltage, clock rate or both, can be altered to decrease power consumption at the price of slower performance. This is sometimes done in real time to optimize the power-performance trade off. Newer Intel Core processors support ultra-fine power control over the function units within the processors.

5.3. Power supply

Power supplies in most computers aren't designed for energy efficiency. In fact, most computers drain more power than they need during normal operation, leading to higher electrical bills and a more dire environmental impact. The 80 Plus program is a voluntary certification system for power-supply manufacturers. If a PSU (Power Supply Unit) meets the certification, it will use only the power it needs at a given load. For example, if the PC requires only 20% of the total power of a 500-watt PSU, the system will consume no more than 100 watts. Only when the PC requires full power will the PSU run at the full wattage load. An 80 Plus power supply can save about 85 kilowatt hours per PC, per year. In many ways, it's the heart of a green PC, since it manages the power for all the other components. It also has the most dramatic effect on your energy bill. Moreover, all 80 Plus power supplies are also lead-free and RoHS compliant.

5.4. Storage capacity and performance

There are three options available, all of which vary in cost, performance and capacity. The most conventional option is the 3.5" desktop hard drive. Recently, major drive manufacturers have begun to focus on reduced power consumption, resulting in such features as the reduced RPM low-power idle mode with fixed rotation speed for reduced power consumption. The advantages of this route are the highest possible capacity, the best performance (out of the highest-end solid-state drives).

The second option, which also lends itself to affordability, is to use a 2.5" laptop hard drive. These consume less power than larger disks as a result of their smaller platters, smaller motors and firmware that is already optimized for power consumption versus most 3.5" hard disks. With capacities up to 320 GB, reasonable capacity is well within reach, although the price is substantially higher than an equivalent 3.5" disk. With a green system aimed at light use, a 120 GB or 160 GB laptop drive is a very affordable, lower-power alternative to a 3.5" disk.

The lowest power option is to use a solid state hard drive (SSD), which typically draw less than one-third the power of a 2.5" disk. The latest, highest-performance SSDs are very fast but extremely expensive and currently top out at only 64GB. That's adequate for light use, but wholly inadequate for gamers, video editing and other heavy uses. More affordable SSDs are available in larger capacities, but are not cheap and typically have slow write performance, which limits their practical utility.

Smaller form factor (e.g. 2.5 inch) hard disk drives often consume less power than physically larger drives. Unlike hard disk drives, solid-state drives store data in flash memory or DRAM. With no moving parts, power consumption may be reduced somewhat for low capacity flash based devices. Even at modest sizes, DRAM based SSDs may use more power than hard disks, (e.g., 4 GB i-RAM uses more power and space than laptop drives). Flash based drives are generally slower for writing than hard disks.

5.5. Displays on the monitors

LCD monitors typically use a cold-cathode fluorescent bulb to provide light for the display. Some newer displays use an array of light-emitting diodes (LEDs) in place of the fluorescent bulb, which reduces the amount of electricity used by the display. LCD monitors uses three times less when active, and ten times less energy when in sleep mode. LCDs are up to 66% more energy efficient than CRTs. LCDs are also upwards of 80% smaller in size and weight, leading to fuel savings in shipping [11]. LCDs produce less heat, which means less AC will be needed to keep cool. LCD screens are also easier on the eyes. Their lower intensity and steady light pattern result in less fatigue versus CRTs. A newer LCD draws 40-60 W maximum in a modest 19", 20" or 22" size. That number grows close to 85 W or 100 W maximum for a 24" unit. Drop them down to standby or turn them off entirely when not using them to minimize power consumption. By comparison, a 21" CRT typically uses more than 120 W, more than double the power of a typical 22" LCD.

5.6. Recycling of materials

Obsolete computers are a valuable source for secondary raw materials, if treated properly, however if not treated properly they are a major source of toxic materials and carcinogens. Rapid technology change, low initial cost and even planned obsolescence have resulted in a fast growing problem around the globe. Technical solutions are available but in most cases a legal framework, a collection system, logistics and other services need to be implemented before a technical solution can be applied. Electronic devices, including audio-visual components (televisions, VCRs, stereo equipment), mobile phones and other hand-held devices and computer components, contain valuable elements and substances suitable for reclamation, including lead, copper and gold. They also contain a plethora of toxic substances, such as dioxins, PCBs, cadmium, chromium, radioactive isotopes and mercury. Additionally, the processing required reclaiming the precious substances (including incineration and acid treatments) release, generating and synthesizing further toxic by-products.

Computer recycling refers to recycling or reuse of a computer or electronic waste. This can include finding another use for the system (i.e., donated to charity) or having the system dismantled in a manner that allows for the safe extraction of the constituent materials for reuse in other products. Additionally, parts from outdated systems may be salvaged and recycled through certain retail outlets and municipal or private recycling centers.

[1] Recycling of computing equipment can keep harmful materials such as lead, mercury and hexavalent chromium out of landfills, but often computers gathered through recycling drives are shipped to developing countries where environmental standards are less strict than in North America and Europe. The Silicon Valley Toxics Coalition estimates that 80% of the post-consumer e-waste collected for recycling is shipped abroad to countries such as China,

India and Pakistan. Computing supplies, such as printer cartridges, paper and batteries may also be recycled as well. [2] While there are several health hazards, when it comes to dealing with computer recycling some of the substances you should be aware of; (i) Lead is common in CRTs, some batteries and to some formulations of PVC. It can be harmful if not disposed of properly, (ii) Mercury is common in fluorescent tubes. With new technologies arising, the elimination of mercury in many new model computers is taking place, (iii) Cadmium is present in some rechargeable batteries. It can be hazardous to skin if exposed for too long, and (iv) Liquid crystals are another health hazard that should be taken into consideration although they do not have the nearly the same effects as the other chemicals.

Most major computer manufacturers offer some form of recycling, often as a free replacement service when purchasing a new PC. At the user's request, they may mail in their old computer, or arrange for pickup from the manufacturer. Individuals looking for environment-friendly ways in which to dispose of electronics can find corporate electronic take-back and recycling programs across the country. Open to the public (in most cases), corporations nationwide have begun to offer low-cost to no-cost recycling and have opened centers nationally and in some cases internationally. Such programs frequently offer services to take-back and recycle electronics including mobile phones, laptop and desktop computers, digital cameras and home and auto electronics. Companies offer what are called “take-back” programs that provide monetary incentives for recyclable and/or working technologies.

5.7. Telecommuting

Teleconferencing and tele-presence technologies are often implemented in green computing initiatives. The advantages are many; increased worker satisfaction, reduction of greenhouse gas emissions related to travel and increased profit margins as a result of lower overhead costs for office space, heat, lighting etc. The savings are significant and 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. Other related initiatives, such as hotelling, reduce the square footage per employee as workers reserve space only when they need it. Many types of jobs-sales, consulting and field service integrate well with this technique.

Rather than traveling great distances, in order to have a face-face meeting, it is now possible to teleconference instead using a multiway video phone. Each member of the meeting, or each party, can see every other member on a screen or screens and can talk to them as if they were in the same room. This brings enormous time and cost benefits, as well as a reduced impact on the environment by lessening the need for travel.

5.8. Cloud computing

Cloud computing has recently received significant attention, as a promising approach for delivering information and communication technology (ICT) services by improving the utilization of data center resources [12, 13]. In principle, cloud computing is energy-efficient technology for ICT provided that it’s potential for significant energy savings that have so far focused on only hardware aspects, can be fully explored with respect to system operation and networking aspects also. Cloud computing results in better resource utilization, which is good for the sustainability movement for green technology [14].

5.9. Data compression

In enterprise, huge amount of data that is stored is someway or other duplicated information. Information system backups are true example of such duplicated data. Intelligent compression techniques can be used to compress the data and eliminate duplicates help in cutting the data storage requirements.

5.10. Other energy efficient methods

For improvement of computer efficiency, particular specifications could help to improve energy efficiency [15]. For example:

- Use a low power desktop or a laptop computer (40-90 watts) rather a higher power desktop (e.g. 300 watts).
- Higher-quality power supplies can be over 80% efficient; higher energy efficiency uses less power directly and requires less power to cool as well. As of 2007, 93% efficient power supplies are available.
- Buy hardware from manufacturers that have a hardware recycling scheme, and recycle your old computer equipment rather than sending it to landfill.
- Use of toxic materials like lead can be replaced by silver and copper.
- Replace your CRT screen with an LCD screen.
- Keep your PC or laptop for at least 5 years. If you're leasing, shift to a 5 year period. This reduces resource and energy consumption associated with the manufacture and distribution of PCs by 40%, compared to replacing PCs every 3 years which is current corporate practice.
- Use Linux (such as Ubuntu), which requires less resources than many other operating systems on an older computer as a spare or a file server.
- Use server virtualization to aggregate multiple under-utilized servers onto more energy efficient server infrastructure.
- Use server and/or web-based applications where possible to extend desktop service life and reduce desktop software maintenance. Establish policies governing the acquisition, usage and disposal of computer hardware to minimize energy consumption and environmental impact.

6. GREEN INITIATIVE

Several green initiatives have currently been undertaken in the computer industry to maximize energy efficiency and e-waste recycling process [16, 17]. To purchase the

computers and other electronic equipment's like routers, printers, air-conditioners etc., the following procurement initiatives could be adopted: (i) Establish standards and benchmarks to define purchasing policy for computers, (ii) Determine environmental evaluation criteria to compare technologies and components, (iii) Utilize reliable third party monitoring and testing organizations independent of suppliers, and (iv) Use existing computer templates from systems contracting tenders as bench-marked specifications for comparative purposes.

The user departments would have to accept these terms and be willing to incorporate Eco-labels and other environmentally friendly functionality into their specifications. Report/update purchase activity in support of green initiatives, including day-to-day progress to sustainability coordinator for incorporation of awareness program.

6.1. Upgrade with efficient components

Upgrading inefficient components inside of a computer can improve a computer's overall efficiency, although higher cost is sometimes a prohibiting factor, with component upgrades sometimes requiring other prerequisite components to be replaced first. A more cost effective alternative to component upgrades is to deliberately seek the greenest computer available when it comes time for replacement.

6.2. Download software

Instead of buying software on disks in plastic packaging, try to download it from the web. Downloading of software saves the materials, packaging, manufacturing and transport costs of a tangible copy and electronic downloads are often cheaper than their counterparts sold in the shops.

6.3. Green purchasing

Green purchasing is the most important purchasing method adopted now-a-days. Customers of every category are being encouraged for green purchasing. One of the ways is purchasing electronic products having labels such as EPA Energy Star (US), TCO 95 (Sweden), and Blue Angel (Germany). This is also encouraging for the companies to manufacture greener products that consumes less power and creates less harm to environment. Different strategies are being followed by different companies in different countries to manufacture their products green.

6.4. Printers and multifunctional devices

It is observed that generally color laser consume much power than ordinary laser printers not only in standby mode but also in sleep mode so there must be proper settings for the printers with respect to the power consumptions.

6.5. Communications and network

Telephone lines, W-LAN routers, DSL modems which are used at any moment in the 24 hours, so there is no standby mode for these devices thereby they are consuming much power so they should be manufactured with low power consuming materials.

6.6. External hard disks

When these devices are connected to the system, they continuously use the power consumption whether they are not in use for read and writing the disk, only few models are manufactured sophisticatedly in the power saving modes, of which Seagate devices are commendable.

7. CONCLUSION

The tremendous growth of IT industries is slowly poisoning the environment. Green computing is an approach that can satisfy the growing demand for network computing without putting such pressure on the environment. Processor and systems could be designed which do not increase demands on the environment, but still provide an increased amount of processing capability to customers to satisfy their business needs. Now the time has come to think about the efficient use of computers and the resources, which are non-renewable. It opens a new window for the new entrepreneurs for harvesting with E-waste material and scrap computers. Green computing is not about going out and designing biodegradable packaging for products. The features of a green computer of tomorrow would be such as energy efficiency, manufacturing and materials, recyclability, service model and self-powering. Green computer will be one of the major contributions, which will break down the 'digital divide', that separates the information rich from the information poor.

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