



RESEARCH ARTICLE

GREEN: The New Color in Computer Technology

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Abstract— Today, Computer is the basic need of every human. A computer made our life easier and saves a lot of time and human efforts, but no one is aware about the harmful impacts of the use of computer on environment. Most of the CO₂ emission is produced through the heat generated by computer and its devices. The energy consumption by various computing devices also plays a main role towards harmful environment. The Toxicity and Pollution are caused due to Computers materials. To solve these Problems “GREEN COMPUTING” comes into existence. With the help of green computing we can save lot of energy and protect our environment from the harmful impacts of computers and its devices. Green computing is an effective approach toward energy efficient products .This Paper provides a brief account of Green Computing. The emphasis of this study is on Benefits of Green Computing, Features of a Green Computer and various Green Technologies are discussed. By adapting Green Computing, “SAVE THE ENVIRONMENT, SAVE YOUR LIFE”.

Key Terms: - Green computing; environment; computer; hazardous; pollution

I. INTRODUCTION

Green computing or Green IT refers to environmentally sustainable computing [2]. It is also the environmentally responsible use of computers and related resources. In 1992, the U.S. Environmental Protection Agency launched a program called “Energy Star”[2]. It is a voluntary labelling program designed to promote and recognize energy-efficiency. One result was the adoption of “sleep mode” in consumer electronics. ‘Green computing’, as a phrase, was used shortly after the Energy Star program was initiated. The primary objective of such a program is to account for the triple efficiently bottom line (or “People, Planet, Profit”).

One of the main objectives of Green Computing is about improving computing performance and reducing the energy consumption & carbon footprints. This term generally relates to the use of computing resources in conjunction with minimizing environmental impact, maximizing economic viability, ensuring social duties, reducing the use of hazardous materials like CFCs, promoting the use of recyclable materials, minimizing use of non-biodegradable components, and encouraging use of sustainable resources.

A green initiative [3] is taken in consideration of all facets of a computer’s life, from design to disposal. Green computing includes -

- ✓ **Green Design** – Designing energy efficient and environmentally sound components, computers, servers, cooling Equipment, and data centers.
- ✓ **Green Manufacturing** – manufacturing electronic components, computers, and other associated subsystems with minimal impact on the Environment.
- ✓ **Green use** – reducing the energy consumption of computers and other information systems as well as using them in an environmentally sound manner.
- ✓ **Green Disposal** – Refurbishing and reusing old computers and properly recycling unwanted computers and other electronic equipment.

Use of computer plays a big role in environment pollution and Degradation .Today there is a great need to implement the concept of Green computing and guide the common people to save our environment. In this paper we discuss the term Green Computing, its Benefits, Features of a green Computer and various green technologies. These technologies are environmentally Sustainable, Cost effective.

II. WHAT IS GREEN COMPUTING

The term “*green*” has always been associated with the name of something that is inclined towards the “*nature*” or something that has to do with the beneficiary of the environment. Green is used in everyday language to refer to environmentally sustainable activities. LMID developed a working definition of green activities that is both rigorous and flexible. The mnemonic GREEN [1] is defined more fully in –

G - Generating and storing renewable energy

R - Recycling existing materials

E - Energy efficient product manufacturing, distribution, construction, installation and maintenance

E - Education, compliance and awareness

N - Natural and sustainable product manufacturing

The term Computing gives you power to imagine new ways of improving our lives by putting better ideas into actual practice in our communities and make a world of difference – reducing energy consumption, enhancing security, reducing pollution, and advancing learning and education.

“Green computing encompasses policies, procedures, and personal computing practices associated with any use of information technology (IT). People employing sustainable or green computing practices strive to minimize greenhouse gases and waste, while increasing the cost effectiveness of IT, such as computers, local area networks and data centre “

Green computing is all about using computers but in a smarter and eco-friendly way. More directly it means using computers in ways that save the environment, save energy and save money.

III. THREE GOOD REASONS TO GO GREEN

Newton’s Third Law of Motion states that “For every action, there is an equal and opposite reaction.”, similarly the consumption of energy sources has a negative reaction on the environment. The computer technology give rise to various environmental problems like global warming, pollution, toxicity, occupational and health hazards, Serious Diseases. Computers are continuously using a large amount of power and consequently regular cooling energy is needed to counteract this power usage. It can be an endless circle of energy waste. So, there is need to Think about it and Remove these problems. One good way is “GO GREEN”. Hence, the three main reasons that made us realize the need for growing green -

- ✓ **To save cost** -Green computing lowers the energy consumption and thereby the power bills by making IT systems more Efficient: using less electricity, designing systems for longer useful lives, reducing the amount of equipment purchased and reducing the amount of waste produced saves money and has a positive environmental benefit. The green equipment will be less expensive in the near future due to efficient consumption of resources.
- ✓ **To reduce environmental problems** –Green Computing Reduce environmental Problems by manufacturing computers with the use of nontoxic materials like lead, Mercury can be replaced by silver , copper and Bamboo. Landfills by E waste can be controlled by making best use of the device by upgrading and repairing in time with a need to make such processes (i.e., upgradation and repairing) easier and cheaper. Formal Recycling is done to reuse the Old computers.
- ✓ **To reduce energy consumption** - Green computing is an effective approach towards Energy Efficient Products. Energy intensive manufacturing of computer parts can be minimized by making manufacturing Process more energy efficient like Power-sucking displays can be replaced with green light displays made of OLEDs, or organic light-emitting diodes. Power Management Functions should be installed in devices. Avoid Putting E waste into dumps, it will not only save Environment but also save energy and materials needed for a whole new computer.

To achieve the above objectives, “GREEN COMPUTING” comes into existence. Now we have needed to implement the green computing on various electronic and electrical devices to save our environment from the harmful impacts. So many approaches are used to implement green computing like – Cloud computing, Virtualization, Telecommunicating, Power management, material recycling, Redeployment etc. But they are not discussed in this paper. In the below section, various features or Tips for a Green computer is discussed. There is a need to follow these tips to make environment healthy and sound. Green computing also helps in increasing Profits in Business. As the below figure1 shows that there is always rise in business from year 2010 to 2016.

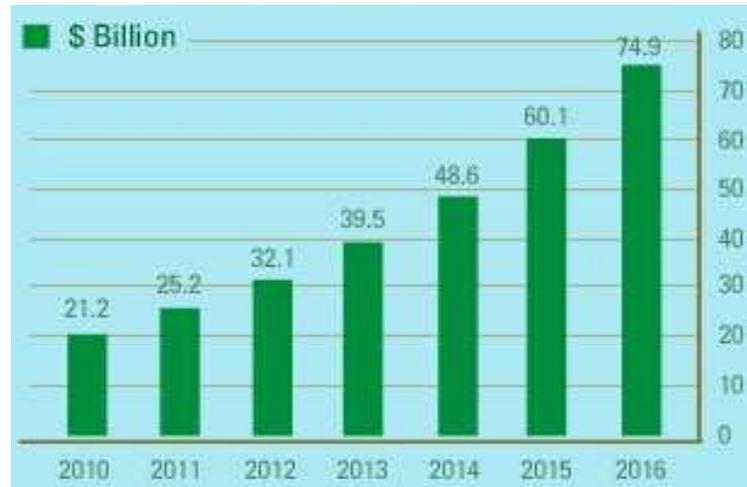


Fig. 1. Potential Business by Green IT Practices

IV. WHAT MAKES A COMPUTER REALLY “GREEN”?

We need not to stop using computers and even need not to stop using electricity but we have to do some efforts to make environment healthy. One such effort is to Buy a “GREEN COMPUTER” .If someone is planning to buy a Green computer [9], but don’t know what to check for? Here’s a list of the features that will help you in deciding whether or not the computer you’re buying is truly green. Opting for a green computer will not just be beneficial for the environment, but it will even be easier on your pocket over the long run because of its low energy consumption.

- ✓ **Low Use of Hazardous Elements:** A lot of hazardous substances are used in the production of a computer ranging from the more lethal ones like cadmium, lead, chromium, and mercury to the relatively less hazardous ones like flame retardants, pesticides, and chlorinated plastics. A green computer's components should ideally be completely free of these lethal substances, as for the less hazardous substances, the focus is on reduction of their use, since their elimination may not be completely possible.
- ✓ **Energy Efficient:** That’s one feature of green computers that pleases not just environmental enthusiasts but also the budget-conscious buyer. Every green computer will have an **ENERGY STAR[2]** rating on it, and the more the stars the more energy efficient the computer will be. Some green computers are also available with the option of running them on renewable energy like solar energy, for which the manufacturers will supply you with all the required accessories.
- ✓ **Recycled Materials Used for Manufacturing:** A truly green computer will have most of its components, especially the plastic ones, made of recycled materials. And the manufacturers are required to declare what percentage of material used in the production of the computer is recycled, with minimum thresholds specified at 10 percent.
- ✓ **End of Life Recovery:** The green computers are designed in such a way that at the end of their life their components can be easily reused, disassembled, or recycled. A minimum of 65% of the parts of the computer should be recyclable or reusable. Apparently, some of the better brands of green computers guarantee a minimum of 90% reusable or recyclable parts.
- ✓ **Use of Renewable and Bio-Based Materials:** Another of the important green computer features is the increased use of renewable or bio-based materials. Again a minimum of 10 percent of such materials should have been used in the production of the green computer components, and the same must be declared.
- ✓ **Longer Product Life:** Green computers come in modular and upgradeable designs with the idea of extending their life cycle. The manufacturers are required to provide a minimum of 3 years' warranty or guarantee, and they must also ensure that the replacement parts will be made available to all buyers up to a minimum of five years. That certainly is one more good reason for you to buy a green computer.
- ✓ **End of Life Take-back Facility:** Every green computer comes with a take-back policy, wherein the manufacturer provisions to take back the computer at the end of its life and offer the buyer a new purchase at a competitive price. So, do verify that the brand of green computer that you’re buying offers a buy-back or take-back.

- ✓ **Manufacturer's Certification:** Before you settle on a particular brand of green computers, you must ensure that its manufacturer has ISO-14001 certification, which is the bare minimum for a manufacturer to qualify as environmental-policy compliant.
- ✓ **Packaging Material:** What's a green computer that comes in a toxic or non-recyclable packaging? Truly, it isn't one! So, do check the packaging material details to see that the material used is completely non-toxic and at least 90% of it is recyclable. It will be even better if the packaging is made of recycled material.
- ✓ **EPEAT ratings[4]:** Before you make your final decision, do a bit of research on www.epeat.net, where all green computers and laptops have been assigned a rating that will clearly tell you how green the computer you're buying is. You can find detailed reports on how each of these computers score, on the different environmental criteria.
- ✓ **Low power Consumption -** The first way to run a green computer is to look for an 80 Plus compliant power supply. These power supplies deliver only the power required to run. For example, if you have a 600-watt power supply but your computer requires only 250 watts to function, an 80 Plus power supply will provide 250 watts.
- ✓ **Power Management -** One easy way to green a computer is to use its built-in settings. Both Windows and Macintosh computers include power-management features that prompt the computer, hard drive and monitor to go into a low-energy sleep mode after a preset period of inactivity. Going smaller is another good way to green a computer. Laptops use significantly less energy than desktops; 40 to 50 watts compared with 200 to 400, respectively. A smaller flatscreen monitor also contributes to a green computer, since energy consumption grows rapidly with monitor size.
- ✓ **Refurbished parts or computers:** Another way to "go green" is to purchase a used or refurbished computer rather than a new model, if your computing needs allow it. Choosing a refurbished desktop or laptop is cost-efficient, and it saves an older computer from being thrown on the scrap heap before it's time is really up.



Fig. 2. Green computer and its features

Figure 2 shows the green computer and various features related to it. By Adapting Green Computing completely, it will definitely "SAVE THE ENVIRONMENT, SAVE YOUR LIFE".

V. SOME GREEN TECHNOLOGIES

Technology is ever-changing and expanding and so any device which is new today will become obsolete tomorrow. Thanks to the advancements happening in the area of computer technology, new computers enter the market and soon remain nothing more than a piece of junk. This is precisely why a new area of computing has emerged, which is popularly known as Green Computing. The Green technology [5] encourages people to use computers as well as accessories that are environmentally-friendly and that cause little or no harm to the environment during their usage or when they are disposed off. Some innovative Energy-Efficient Technologies in the area of computers are explained below-

- A. **Wi-Fi Scheduler -** Wi-Fi scheduler is a simple but very useful application which will allow you to manage and schedule to configure specific hours when the wireless network will be powered On or off

to save energy and enhance security. It is very useful for saving battery life by scheduling Wi-Fi to turn off when you know you won't be using it, like when you're at work or asleep for example.

- B. **Wake on Lan-** Wake-on-LAN (WOL) is an ethernet computer networking standard that allows a computer to be turned on or awakened by a network message. The message is usually sent by a program executed on another computer on the same local area network. It is also possible to initiate the message from another network by using subnet directed broadcasts or a WOL gateway service.
- C. **Power saving by Link Status** - When a computer or network equipment is shut down, switches often remain on and continue to consume considerable amounts of power. But this Green Technology allows switches to automatically detect link status and reduce power usage of ports that are idle. Switch can detect whether or not a device is connected to each port. If no device is connected to a port, the switch will automatically power down that port. This switch will save 73% of power as compare to normal switch when all ports are idle as shown in figure3. Examples of Green Switches are-
 - 16/24-Port Unmanaged Gigabit Switch series
 - TL-SG1005D 5-Port Gigabit Desktop Switch



Fig. 3. Normal switch compared with Link switch

- D. **Power Saving by Cable Length** - Green verified switches have the ability to analyze the length of any Ethernet cable connected to them for adjustment of power usage accordingly, helping you save energy without affecting networking performance. Ideally, shorter cable would use less power because of less power degradation over their length; this is not the case with most devices as they will use the same amount of power across the cable regardless of the length. Power Saving is shown in figure4.

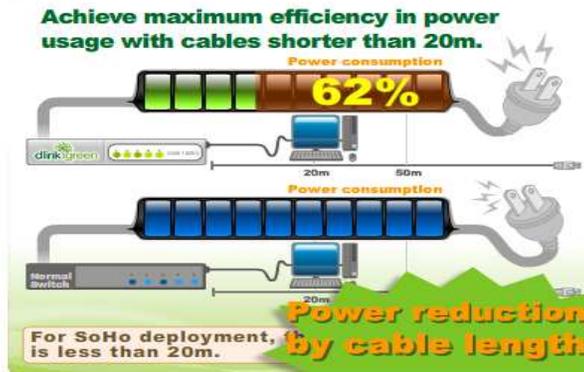


Fig. 4. Power saving by cable length

- E. **Power Saving by Hard Drives Hibernation** - In conventional network attached storage (NAS) systems, hard drives are constantly spinning even when they are not actively being accessed. With green hard drive power management, the hard drive is automatically powered down during periods of inactivity, saving power, reducing heat and prolonging the life of the equipment.
- F. **Digital Photo Frame Power Saving (Motion Detection Sensor)** - Rather than constantly powering a device, the motion detection sensor detects if people are within the vicinity. When users are not present, the device automatically turns off to minimize energy consumption.
- G. **LCD Standby** - Devices with LCDs such as photo frames and storage routers include a feature to automatically disable the screen/backlight when no motion or activity is detected.
- H. **Share port** - Share Port technology saves power by eliminating the need to connect a printer or storage device to a dedicated PC or print server as shown in figure 5.

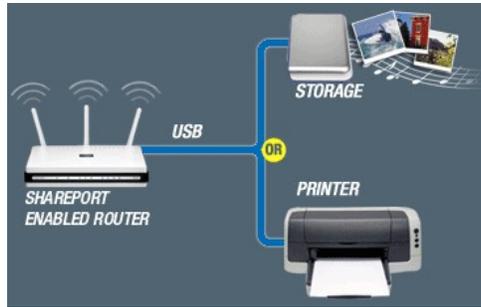


Fig. 5. Shareport Enabled Router

- I. **Smart FAN** - Conventionally, fans in network equipment run constantly regardless of if they are needed or not. Green technology makes use of Smart Fan technology to automatically turn off or lower the speed of the fan to reduce noise and power consumption whenever system temperatures are low. Regulates the speed of the fan based on an increase or decrease in temperature.
- J. **Time-Based Power over Ethernet (PoE)** - Time-based PoE optimization turns PoE on or off based on a schedule to save power. When PoE devices are not in use (i.e. during the night, or on the weekend) PoE be disabled until needed. Figure 6 is showing POE and other connected devices.

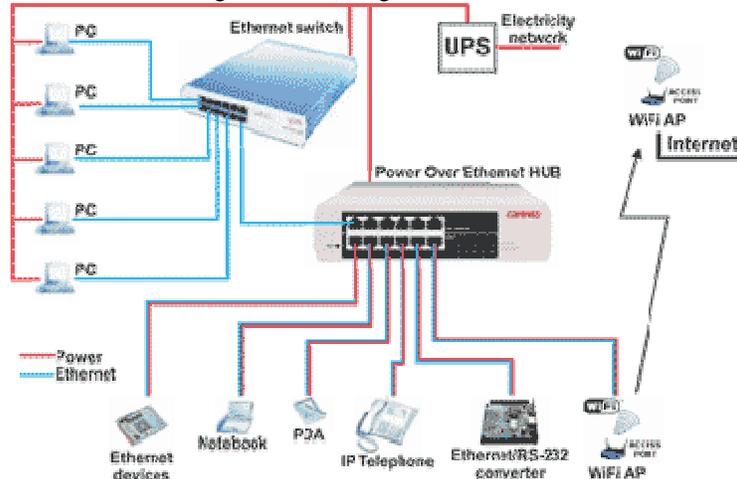


Fig. 6. Power over Ethernet hub

- K. **Wireless On/Off Button** - Even when wireless connection is not needed it is still being used. This function allows users to simply turn off the function, which saves energy. The Wireless On/Off button allows customers to turn off the wireless portion of their router/gateway when not in use. A wireless router consumes up to 30% less power with the wireless turned off, then with it on. Turning off wireless also has a security benefit, since it prevents anyone from hacking into the wireless network.
- L. **Power on/off Button** - The Power On/Off button allows customers to turn off their router/gateway when not in use. Products without an on/off button can only be powered down by physically unplugging it, and in many cases the cord falls behind a desk in a mess of cables, making it very difficult to find later. For this reason, many customers do not power down their routers, and therefore consume more energy when needed. The Power On/Off button addresses this issue.
- M. **Green Web Surfing** - There are green search engines [8], green shopping sites, and even green dating sites - it's an impressive abundance of good intentions. Many initiatives have been taken to make the entire web surfing experience more green, i.e. eco-friendly.
 - **Greener Google Browsing** - Blackle.com claims to help you save energy by offering a version of Google that has a black background, which may cut down on your display's electricity consumption.
 - **Being Green with Google & Yahoo** - Google and Yahoo search engines are also making efforts to be greener. Google has created a system where in web developers who are willing to incorporate Google Search on their websites would have a small share in the advertising revenue. The steady flow of funds for green causes is generated from advertising revenues.
 - **Greener FireFox Surfing** - One of the most talked-about green surfing tools that had been introduced was the Flock (the eco edition). It made surfers to make a significant contribution

to the cause just by being online. It was named as the first comprehensive *green browser*. It was powered by Mozilla Firefox and used Yahoo's search engine.

N. **Green Laptops - Green** Laptops are innovative Energy Efficient Laptops which are eco-friendly. Green Laptops are Recyclable, Nontoxic, Disposable. They consume less power with LED-backlit displays. They support 100% recyclable packaging. Examples of Green Laptops are as follows-

- Recyclable paper laptop - One of the most environmentally friendly computers that you can think of purchasing is the Recyclable Paper Laptop. This concept laptop is crafted from papers that have been recycled or pulp materials that are essentially packed in layers.
- Bamboo Laptops [6] - Bamboo has a tensile strength that rivals that of steel, and it's a perfect substitute for plastic. The packaging is also eco-friendly, so it's 100% natural and recyclable. The laptops use a bamboo frame and even the track pad is made out of bamboo as shown in figure 7. Bamboo laptop depicts an incredible and perhaps the most visible union of nature and technology. Bamboo laptops are green from design and production to recycling and disposal. Apart from being easy to grow, it also reduces CO₂. These characteristics of bamboo make it an ideal choice for environmental friendly laptops.



Fig. 7. Bamboo Laptop

- Lenovo ThinkPad Laptops [7] - The L-series laptops are made from 30% post-consumer recycled content. The greenness also affects the bottom line, as this laptop is supposed to save you 40% on operating costs alone. It has an LED-backlit display and power manager. The packaging is recyclable and there's 20% less of it to go to waste. It is a complete Green Laptop.

VI. CONCLUSION

This paper helps to aware a common man about the term Green computing and various benefits of green computing towards sustainable environment. As consumers haven't cared about ecological impact when buying computers, they've cared only about speed and price. But there is need to aware the consumers about Green Computer. The features of a green computer are discussed in this Paper. New green materials are developed every year, and many toxic ones are already being replaced by them. Green computer will be one of the major contributions toward Green Computing. Different Innovative Green Technologies are Discussed which are environmentally sustainable products. By Adapting "Green Computing", "SAVE THE ENVIRONMENT, SAVE YOUR LIFE".

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