Green Computing: An Overview with Reference to India

[1]Srinjoy Nag Chowdhury, [2]Kshitij Manohar Kuhikar, [3]Akshay Agnihotri

[1]ECE Department, [2]CCE Department, Manipal University Manipal, Karnataka, India
Email: [1]rahulsrinjoy@gmail.com, [2]kshitijkuhikar@ymail.com, [3]akshayagnihotri2110@gmail.com

Abstract— In today's world the driving force of computing has shifted from faster analysis, speedier calculations and solving of more complex problems to achieving energy efficiency, minimization in consumption of electronic equipments, minimization of e-waste and use of non-toxic materials in preparation of electronics. The practice of using computing resources efficiently is gaining serious momentum and thus the goals of reducing the use of hazardous materials, maximizing energy efficiency during the product's lifetime, and promotion of recyclability or biodegradability of defunct products and factory waste are being realized. This radical change in perspective amongst the developers has led to a revolution in the field of computing technology and this revolution has been coined as green computing. Green computing is basically the study and practice of efficient and eco-friendly computing which will help a typical organization to reduce their energy footprint while maintaining required levels of computing performance. In this paper we review the need of green computing, its journey from its origin to its where it stands now. Then we delve into the approaches to green computing, the practices undertaken, and the industry and government initiatives. We further go on to introduce a few novel ideas so as to how a small business or an average user can realize the idea of green computing and lastly we look at how India is positioned in this respect.

Keywords— ACPI, Asus Eee pc, BEE, BFR, BIOS, Blackle, Carbon credit policy, carbon footprints, CIOs, CPU, CRT, CSCI, CTRB, DIT, DRAM, duEDF, e-waste, electronic archiving, end-of-life management, Energy Star, EPEAT, Fit-PC, flash memory, GCIO, GHG, greenhouse, green computing, green passport, HP Planet Partners, HVAC, ICT, infra sharing, ITES, Linux, MAC, mobile computing, NAPCC, netbooks, OLED, PBB, PBDE, Phonebloks, processors, PVC, RET, RoHS, server farms, SRA, SSD, Sunray thin client, TCO, TRAI, ultra-portables, virtualization, WWF, Zonbu Computer.

I. INTRODUCTION

The field of Green Technology encompasses a broad range of subjects from new energy generation techniques to the study of advanced materials to be used in our daily life. Green technology focuses on reducing the environmental impact of industrial processes and on innovative technologies caused by the Earth's growing population. It has taken upon itself the goal to provide society's needs in ways that do not damage or deplete natural resources. Mainly this means creating fully recyclable products, reducing pollution, proposing alternative technologies in various fields, and creating a center of economic activity around technologies that benefit the environment. Green computing is the environmentally responsible use of computers and related resources. Such practices include the implementation of energy-efficient Central Processing Units (CPUs), Servers and Peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste). Taking into consideration the popular use of information technology industry, it has to lead a revolution of sorts by turning green in a manner no industry has ever done before. The plan towards green IT should include new electronic products and services with optimum efficiency and all possible options towards energy saving. Modern IT systems rely upon a complicated mix of people, networks and hardware; as such, a green computing initiative must be systemic in nature, and address increasingly sophisticated problems. Elements of such a solution may comprise items such as end user satisfaction, management restructuring, regulatory compliance, disposal of electronic waste, telecommuting, virtualization of server resources, energy use, thin client solutions, and return on investment (ROI). As the technology in this century will get no less complicated and devices made will be no simpler than they are now,

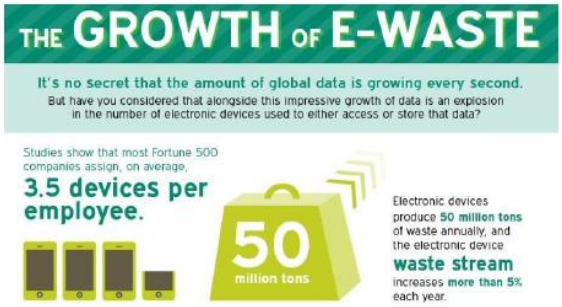

Figure 1: Statistics of E-waste

this emerging field of computing will be the one to look out for. [1][2]

II. GREEN COMPUTING: IT'S NEED

In today's world, IT systems analyze and record huge amounts of data which ranges from business transactions to phone records to what not. All this constant storing of data in data centers and setups like data warehouses need huge amount of power to run the servers and maintain them. This rise in energy to manufacture, store, operate, and cool computing systems has grown significantly in the recent years and this in turn has led to figures such as a whopping 60.5 billion kilowatt-hours of electricity at an estimated cost of $4.2B annually. [3] With energy crisis knocking at the door and with this amount of improper energy utilization, these setups can no longer go on. This fundamentally basic question gives rise to the need of diverse non-traditional systems which can successfully synchronize the data footprint with the hardware footprint and create a system by the virtue of which optimum space and server resources can be utilized. Furthermore green computing can lead us to achieve a four point agenda as follows [3]:

- Reduce energy consumption/power requirement.
- Save power/cut own cost.
- Use eco-friendly sources of energy and thereby prevent climate deterioration.
- Reduce harmful effects of computing resources.

Thus one can easily observe why and how green computing has become the next big thing on the technology scenario.

III. HISTORY

It started in the 1990s, when the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program 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. Subsequently the Swedish organization TCO Development launched the TCO Certification program to promote low magnetic and electrical emissions from CRT-based computer displays. This program was later expanded to include criteria on energy consumption, ergonomics, and the use of hazardous materials in construction. This paved the way for green computing to be taken up seriously at an international level. [13]

IV. KEYS TO GREEN COMPUTING

1. Green Use

Tumbling the energy consumption of computers and other information systems as well as using them in an environmentally sound manner.

2. Green Disposal

Restoring and reusing old computers and properly recycling unwanted computers and other electronic equipment.

3. Green Design

Devising energy-efficient and environmentally sound components, computers, servers, cooling equipment, and data centers.

4. Green Manufacturing

Producing electronic components, computers, and other associated subsystems with minimal impact on the environment.

V. PRACTICES IN GREEN COMPUTING

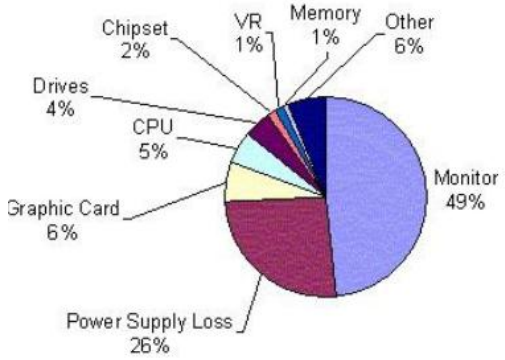

Figure 5.1: Component wattage

1. Virtualization

Computer Virtualization means abstraction of computer resources, such as the process of running two or more logical computer systems on one set of physical hardware. Through Virtualization, a system administrator can combine several physical systems as virtual machines on one single, powerful system, thereby reducing power and cooling consumption. In the longer run, more profits and less expenses. Reducing the number of hardware components and replacing them with Green Computing systems reduces energy costs for running hardware and cooling as well as reduces carbon dioxide emissions and conserves energy.

2. Algorithm Efficiency

The efficiency of algorithms has an impact on the amount of computer resources required for any given computing function and there are many efficiency trade-offs in writing programs. Algorithms such as Slack Reduction Algorithm (SRA), Integer-bit power allocation algorithm, duEDF algorithm, Computation and Transmission Rate Based Algorithm (CTRB) help in reducing the pressure on the hardware and let smart computing take its course.

3. Improved Data Center Cooling Methods

This is achieved by improving the data center cooling configuration, eliminating considerable amount of

energy leaks. It can result in efficient data centers by following leading practices in data center layout and rack and server arrangements. Effective approach include raised floors to improve airflow, moving cooling systems closer to servers to concentrate cold air in the right place, alternating hot and cool server passageway to improve airflow and using water-based air conditioning systems.

4. Power Management

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.

5. Power Supply

Desktop computer power supplies (PSUs) are generally 70–75% efficient, dissipating the remaining energy as heat. An industry initiative called 80 PLUS certifies PSUs that are at least 80% efficient; typically these models are drop-in replacements for older, less efficient PSUs of the same form factor. As of July 20, 2007, all new Energy Star 4.0-certified desktop PSUs must be at least 80% efficient.

6. Storage

Smaller form factor hard disk drives often consume less power per gigabyte 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., 4GB I-RAM uses more power and space than laptop drives).

7. Display

LCD monitors typically use a cold-cathode fluorescent bulb

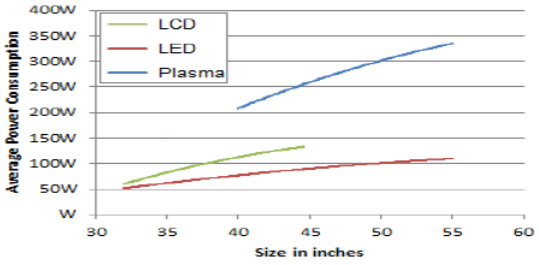

Figure 5.2: Power consumption by size

to provide light for the display. Some newer displays use an array of light-emitting diodes (LEDs/OLEDs) in place of the fluorescent bulb, which reduces the amount of electricity used by the display.

VI. INDUSTRY AND GOVERNMENT SCHEMES

1. Government Initiative

Many government agencies have continued to implement standards and regulations that encourage green computing. The Energy Star program was revised in October 2006 to include stricter efficiency requirements for computer equipment. The European Union's directives 2002/95/EC (RoHS), on the reduction of hazardous substances, and 2002/96/EC (WEEE) on waste electrical and electronic equipment required the substitution of heavy metals and flame retardants like PBBs and PBDEs in all electronic equipment put on the market starting on July 1, 2006. The directives placed responsibility on manufacturers for the gathering and recycling of old equipment (the Producer Responsibility model).

2. Industry Initiative

1) Climate Savers Computing Initiative: CSCI is an effort to reduce the electric power consumption of PCs in active and inactive states. The CSCI provides a catalog of green products from its member organizations and information for reducing PC power consumption. It was started on 2007-06-12.

2) Green Computing Impact Organization Inc.: GCIO is a non-profit organization dedicated to assisting the end-users of computing products in being environmentally responsible. This mission is accomplished through educational events, cooperative programs and subsidized auditing services. The heart of the group is based on the GCIO Cooperative, a community of environmentally concerned IT leaders who pool their time, resources, and buying power to educate, broaden the use, and improve the efficiency of green computing products and services.

3) Green Electronics Council: The Green Electronics Council offers the Electronic Products Environmental Assessment Tool (EPEAT) to assist in the purchase of "green" computing systems. The Council evaluates computing equipment on 28 criteria that measure a product's efficiency and sustainability attributes. On 2007-01-24, president George W. Bush issued Executive Order 13423, which requires all United States Federal agencies to use EPEAT when purchasing computer systems.

4) The Green Grid: It is a global consortium dedicated to advancing energy efficiency in data centers and business computing ecosystems. It was founded in February 2007 by several key companies in the industry – AMD, APC, Dell, HP, IBM, Intel, Microsoft, Rackable Systems, SprayCool, Sun Microsystems and VMware. The Green Grid has since grown to hundreds of members, including end users and government organizations, all focused on improving data center efficiency.

VII. ROLE OF COMPUTING COMPANIES

1. Apple

Four areas of particular attention are product and packaging design, materials, energy efficiency, and recycling. Each aspect of the design cycle provides significant challenges, yet their efforts in these areas have resulted in some impressive results.

Figure 7.1: Apple Cycle

1) Product design: It all begins here. Reducing the environmental impact of our products starts with the product design phase. Design dictates the quantity of raw materials as well as the type and recyclability of materials used. It also determines how much energy is consumed during manufacturing and product use. For example, the amazingly slim 20-inch iMac is made from highly recyclable glass and aluminum, and it is so energy efficient that it consumes about the same amount of power as a standard light bulb when on.

2) Materials: Apple helps to safeguard the environment - as well as consumers' safety – by restricting the use of environmentally harmful compounds in their materials and manufacturing processes. In addition to the substances that have already been restricted or eliminated, Apple is removing elemental forms of bromine and chlorine from their products, not just polyvinyl chloride (PVC) and brominated flame retardants (BFRs). The new MacBook family also uses mercury-free light-emitting diode (LED) displays, with arsenic-free display glass.

3) Energy efficiency: A device's greatest contribution to greenhouse gas emissions comes from its consumptions of energy over time. Apple has made great strides in recent years to optimize the energy efficiency of our hardware and created tools, such as the Energy Saver feature in Mac OS X, that allow consumers to manage the power consumption of their computers. Since 2001, Apple desktop computers, portable computers, and displays have earned the 'Energy Star' rating.

5) Recycling: Apple's holistic, lifecycle approach to recycling includes using highly recyclable materials in products in addition to providing extensive take-back programs that enable consumers and businesses to safely dispose of used Apple equipment. Since their first take-back initiative began in Germany in 1994, they have instituted recycling programs in 95 percent of the countries where their products are sold - diverting over 53million pounds of electronic equipment from landfills worldwide. Apple is on track to eliminate toxic chemicals from their products. In the 2008 Environmental Update, Steve Jobs provides an overview on Apple's progress to eliminate mercury and arsenic from displays and Brominated Flame Retardants (BFRs) and Polyvinyl Chloride (PVC) from internal components. Steve Jobs also talks about Apple's policy on climate change, steps taken to improve product energy-efficiency as well as overall recycling performance during 2007.

2. Wipro

Wipro Limited, a leading player in Global IT and R&D services, is committed towards environmental sustainability by minimizing the usage of hazardous substances and chemicals which have potential impact on the ecology. It has joined hands with WWF India, one of the largest conservation organizations in the country, to directly deal with issues of climate change, water and waste management, and biodiversity conservation.

Figure 7.2: Wipro's Portfolio

3. Google

Google's mission is to organize the world's information and make it universally accessible and useful. Hundreds of millions of users access their services through the web, and supporting this traffic requires lots of

computers. They strive to offer great internet services while taking their energy use very seriously. That's why, almost a decade ago, they started their efforts to make their computing infrastructure as sustainable as possible. Today they are operating what they believe to be the world's most efficient data centers. The graph below shows that their Google-designed data centers use considerably less energy - both for the servers and the facility itself - than a typical data center. As a result, the energy used per Google search is minimal. In fact, in the time it takes to do a Google search, one's own personal computer will use more energy than they will use to answer one's query.

But sustainability is about more than electricity, so they've gone beyond just reducing their energy consumption. Before the end of 2008 two of their facilities will run on 100% recycled water, and by 2010 they expect recycled water to provide 80% of their total water consumption. They also

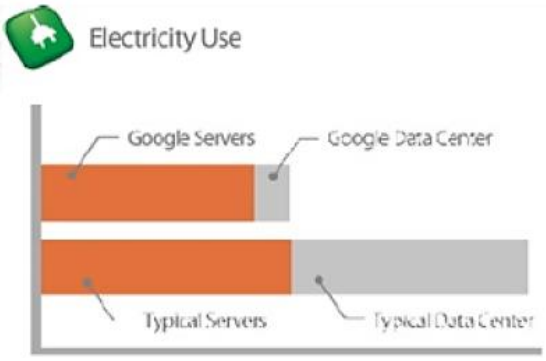

Figure 7.3: Google electricity usage

carefully manage the retirement of their servers to ensure that 100% of this material is either reused or recycled. Finally, they are engaging their users and peers to help build a clean and efficient energy future. This broader impact could be significant; if all data centers operated at the same efficiency as theirs, the U.S. alone would save enough electricity to power every household within the city limits of Atlanta, Los Angeles, Chicago, and Washington, D.C. Sustainability is good for the environment, but it makes good business sense too. Most of their work is focused on saving resources such as electricity and water and, more often than not, these actions lead to reduced operating costs. Being "green" is essential to keeping their business competitive. It is this economic advantage that makes their efforts truly sustainable.

VIII. RECENT IMPLICATIONS OF GREEN COMPUTING

1. Blackle

Blackle is a search-engine site powered by Google Search. Blackle came into being based on the concept that when a computer screen is white, presenting an empty word or the Google home, one's computer consumes 74W. When the screen is black, it consumes only 59W. Based on this theory if everyone switched from Google to Blackle, mother earth would save 750MW each year. This was a really good implementation of Green Computing. The principle behind Blackle is based on the fact that the display of different colors consumes different amounts of energy on computer monitors. 6.2 Fit-PC is a tiny PC that draws only 5w. It is the size of a paperback and absolutely silent, yet fit enough to run Windows XP or Linux. Fit-PC is designed to fit where a standard PC is too bulky, noisy and power hungry. If one ever wished for a PC to be compact, quiet and green, then fit- PC is the perfect fit. It draws only 5 Watts, consuming in a day less power than a traditional PC consumes in 1 hour. One can leave fit-PC to work 24/7 without making a dent in one's electric bill. [12]

2. Zonbu Computer

Zonbu is a new, very energy efficient PC. It consumes just one third of the power of a typical light bulb. The device runs the Linux operating system using a 1.2 gigahertz processor and 512 Mb of RAM. It also contains no moving parts, and does even contain a fan. One can get it for as little as US$99, but it does require one to sign up for a two-year subscription. [11]

3. Sunray thin client

Sun Microsystems is reporting increased customer interest in its Sun Ray, a thin desktop client, as electricity prices climb, according to Subodh Bapat, vice president and chief engineer in the Eco Responsibility office at Sun. Thin clients like the Sun Ray consume far less electricity than conventional desktops, he said. A Sun Ray on a desktop consumes 4 to 8 watts of power, because most of the heavy computation is performed by a server. Sun says Sunrays are particularly well suited for cost-sensitive environments such as call centers, education, healthcare, service providers, and finance. PCs have more powerful processors as well as hard drives, something thin clients don't have. Thus, traditional PCs invariably consume a substantially larger amount of power. In the United States, desktops need to consume 50 watts or less in idle mode to qualify for new stringent Energy Star certification. [9]

4. The Asus Eee PC and other ultra-portables

The "ultra-portable" class of personal computers is characterized by a small size, fairly low power CPU, compact screen, low cost and innovations such as using flash memory for storage rather than hard drives with spinning platters. These factors combine to enable them to run more efficiently and use less power than a standard form factor laptop. The Asus Eee PC is one example of an ultraportable. It is the size of a paperback, weighs less than a kilogram, has built-in Wi-Fi and uses flash memory instead of a hard drive. It runs Linux too. [10]

IX. NOVEL PROPOSALS FOR CREATING A GREENER COMPUTER ENVIRONMENT

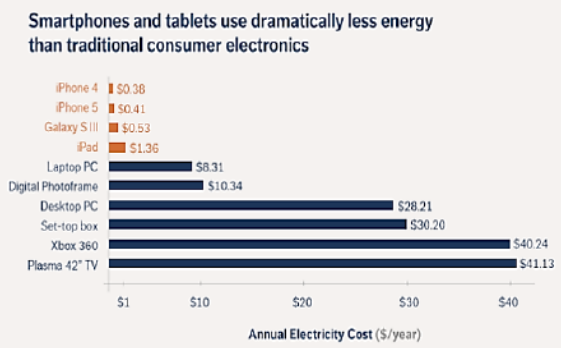

Figure 9.1: Computing devices' power usage pattern

1. Mobile Computing

One should shift towards using smart phones, tablets, netbooks and other light duty computing devices for applications such as surfing internet, chatting, gaming, social networking, downloading, desktop computing including documents, spreadsheets or presentation making or just watching photos and videos. Tablet based devices consume very less power and with the faster processors, more ram, faster wireless internet connectivity and larger memories that they have these days, they are ideal for managing day to day services. Thus, by doing so we are using less power and promoting the cause of green computing. [6]

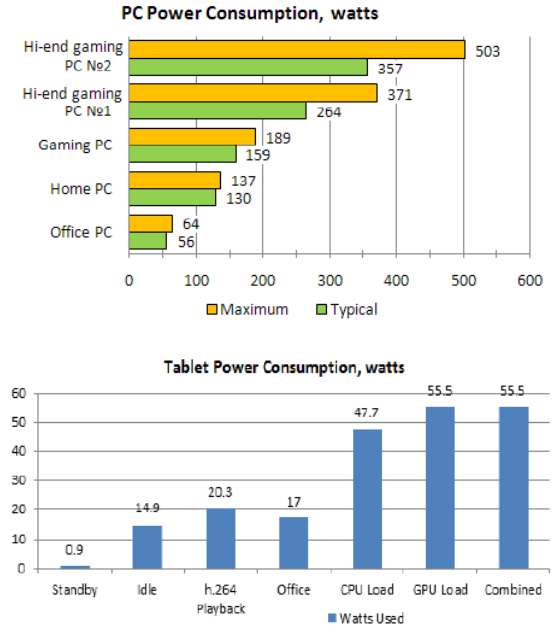

Figure 9.2: Usage-wise analysis of PC and tablet

2. Promoting phonebloks

Current mobile devices are not at all the answer to the cause of reducing e-wastes. If we have to create a greener environment, then we need a radical shift in technology which destroys our current habit of changing between phone models and dumping the old mobile phone for a new one. This radical change would mean the development of a modular telephone system which would, in other words, mean a user could keep a mobile phone forever.

Phonebloks aims to turn one's phone into a completely different type of device. One that, like a desktop computer, can be upgraded and modified to one's own liking. The idea is that one would have one's base (like a circuit board), in which one can install little blocks that carry phone parts. Phonebloks' main focus is that one can upgrade phone parts at will and hence one would never have to throw away full phones. Whether they are broken or outdated, phones usually wouldn't need much to work great. If something breaks, one would just be able to replace a block, instead of the whole phone. [4]

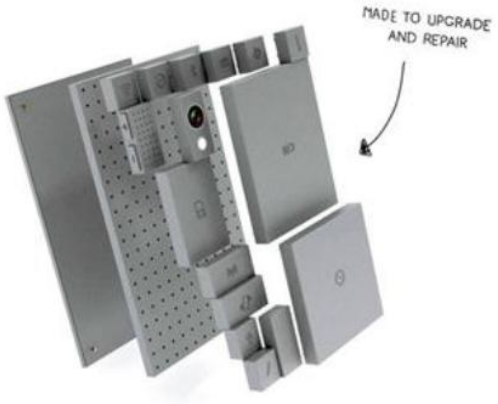

Figure 9.3: Phonebloks

X. GREEN IT INITIATIVE IN INDIA

In response to the world revolution in the field of green IT, India is also moving towards embracing it with open arms. Adopting green IT and sustainability solutions are emerging as key concerns for businesses, investors and technologists across industries and policy makers in India. Operational cost of making energy-efficient resources available is pressuring CIOs in Indian companies to develop strategies to optimize ICT utilization, including companywide energy management, while not compromising on growth or deployment of newer technologies. Amongst government policy initiatives also plans such as the National Action Plan on Climate Change (NAPCC) which outlines the nation's strategy to manage greenhouse gas (GHG) emissions and Indian Economic Survey and India's 12th Five Year Plan which sites Inclusion of Green IT shows the significance given to it by the Indian Diaspora. Given below are some of the guidelines which are set for the IT and the telecom industry in India to follow for a greener future.

The recommendations by the Task Force formed for growth of IT, ITES and manufacturing in India are as follows:

- Standardization – There is a need for interoperable open standards for all the devices including networking equipments which is a

prerogative of BEE and DIT. Need to standardize IT equipments and also benchmarks for data centers for a cleaner and greener environment is required.

- Government Procurement – Government agencies should include the standards for energy consumption as the technical standards in government purchases, and with establishment of mutual agreeable standards for a greener computing environment between BEE and IT industry, it should be made mandatory in all the government purchases.
- Setting up center of excellence – Government of India should set up COE (Centre of Excellence) in the top technical institutions and universities. The centers can become the testing grounds and prototypes/pilot evaluation stages for the green clean technologies.
- Tax Incentives – Investing in the clean technology is a costly affair when the organization is an early mover/adopter. Tax incentives on the production of cleaner technologies and also for the user of the same are needed for better adoption.
- The impetus of green computing has been envisioned for the telecom center too, with government initiatives especially DoT's Recommendation on adoption of Green Technologies in Telecom Sector, such as
- At least 50% of all rural towers and 20% of the urban towers are to be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015; Further 75% of rural towers and 33% of urban towers are to be powered by hybrid power by 2020.
- All telecom products, equipments and services in the telecom network should be certified "Green Passport [GP]" by the year 2015. Telecommunication Engineering Centre will certify telecom products, equipments and services on the basis of ECR ratings.
- All service providers should declare to TRAI, the carbon footprint of their network operations. The Declaration of the carbon footprints should be done twice in a year.
- Service providers should adopt a Voluntary Code of Practice encompassing energy efficient Network Planning, infra-sharing, deployment of energy efficient technologies and adoption of Renewable Energy Technology (RET) to reduce carbon footprints.
- Service providers should evolve a 'Carbon Credit Policy' in line with carbon credit norms with the ultimate objective of achieving a maximum of 50% over the carbon footprint levels of the Base Year (2011) in rural areas and achieving a maximum of 66% over the carbon footprint levels of the Base Year in urban areas by the year 2020.
- Service providers should aim at Carbon emission reduction targets for the mobile network at 5% by the year 2012-2013, 8% by the year 2014-2015, 12% by the year 2016-2017 and 17% by the year 2018-2019.

On a whole India is about to spend up to $70 billion in the year 2015 which is about double the amount of $35 billion which was spent in 2010 and $25 billion more than was done in 2012. Thus, one can easily observe that India which was once among the famous dumping ground of e-wastes in the world has finally risen to the task of eco-friendly computing. [5]

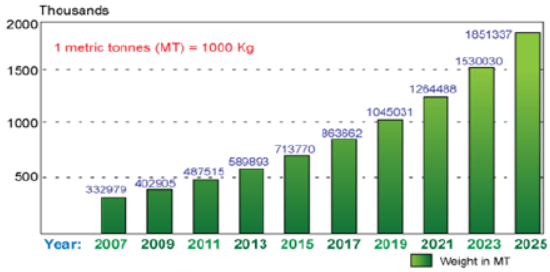

Figure 10: Growth of e-waste in India

XI. GREEN COMPUTING STRATEGIES FOR SMALL BUSINESSES

1. Develop a sustainable green computing plan

Discuss with your 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 machines. Organizational policies should include communication and implementation.

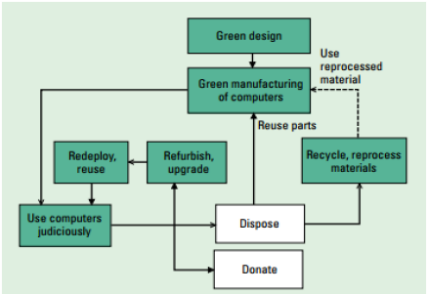

Figure 11: A schematic of ideal green business model

2. Recycle

Discard used or unwanted electronic equipment in a convenient and environmentally responsible manner.

Computers have toxin metals and pollutants that can emit harmful emissions into the environment. Never discard computers in a landfill. Recycle them instead

through manufacturer programs such as HP' Planet Partners recycling service or recycling facilities in your community or donate still-working computers to a non-profit agency.

3. Make environmentally sound purchase decisions

Purchase Electronic Product Environmental Assessment Tool 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.
- Provide a clear, consistent set of performance criteria for the design of products.
- Recognize manufacturer efforts to reduce the environmental impact of products by reducing or eliminating environmentally sensitive materials, designing for longevity and reducing packaging materials.

All EPEAT-registered products must meet minimum requirements and be energy efficient to reduce emissions of climate-changing greenhouse gases. To demonstrate corporate social and environmental performance, manufacturers must offer safe end-of-life management and recycling options when products become unusable.

4. Reduce Paper Consumption

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

5. Conserve energy

Turn off your computer when you know you won't 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. By simply hitting the keyboard or moving the mouse, the computer or monitors awakens from its low-power sleep mode in seconds. Power management tactics can save energy and help protect the environment. [7]

XII. FUTURE SCOPE

As 21st century belongs to computers, gizmos and electronic items, energy issues will get a serious ring in the coming days, as the public debate on carbon emissions, global warming and climate change gets hotter. If we think

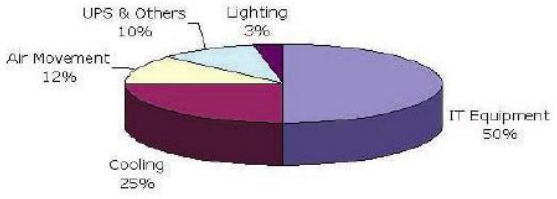

Figure 12: Computer power wattage

computers are nonpolluting and consume very little energy, we need to think again. It is estimated that out of $250 billion per year spent on powering computers worldwide, only about 15% of that power is spent computing; the rest is wasted idling. Thus, energy saved on computer hardware and computing will equate tons of carbon emissions saved per year. Taking into consideration the popular use of information technology industry, it has to lead a revolution of sorts by turning green in a manner no industry has ever done before. Opportunities lie in green technology like never before in history and organizations are seeing it 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. Faster processors historically use more power. Inefficient CPU's are a double hit because they both use too much power themselves and their waste heat increases air conditioning needs, especially in server farms--between the computers and the HVAC. The waste heat also causes reliability problems, as CPU's crash much more often at higher temperatures. Many people have been working for years to slice this inefficiency out of computers. Similarly, power supplies are notoriously bad, generally as little as 47% efficient. And since everything in a computer runs off the power supply, nothing can be efficient without a good power supply. Recent inventions of power supply are helping fix this by running at 80% efficiency or better. [8]

1. ¾ landfills 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.

2. ¾ avoiding the discarding will not only control e-waste out of dumps but also save energy and materials needed for a whole new computer.

3. ¾ power-sucking displays can be replaced with green light displays made of OLEDs, or organic light-emitting diodes.

4. ¾ use of toxic materials like lead can be replaced by silver and copper.

5. ¾ making the recycling of computers (which is expensive and time consuming at present) more effective by recycling computer parts separately with an option of reuse or resale.

6. ¾ future computers could knock 10 percent off their energy use just by replacing hard drives with solid-state,

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

XIII. FINAL REMARKS

Adopting Green Computing Strategies make sense not only from an ethical or moral stand-point, but from a commercial stand-point also. There are umpteen business benefits achievable through the implementation of a green computing strategy such as cost saving, resilience, disaster recovery, business continuity planning and, of course, public relations. Even individuals can aid to the cause of reducing e-wastes and efficient utilization of energy by adopting greener practices. The computing industry is more prepared and far more competent than almost any other industry when it comes to facing and responding to rapid change. Thus, one can certainly hope that it will only take a matter of years to reach a state of affairs where most computers are using far less power than they unknowingly waste today.

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